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THE UNIVERSITY OF ALBERTA

NONVERBAL MEMORY ASSESSMENT USING TWO FORMS OF A COMPLEX FIGURE TEST

by

LORRAINE JANET BREAULT

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

IN

COUNSELLING PSYCHOLOGY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

(Spring 1990)

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled NONVERBAL MEMORY ASSESSMENT WITH A COMPLEX FIGURE TEST submitted by Lorraine Janet Breault in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

The purpose of this dissertation is to compare and validate two measures of nonverbal memory in a psychiatric setting: the Rey-Osterrieth Complex Figure Test (CFT) and the Sequential Complex Figure Test (SCFT). A major problem with the CFT is that successful reproduction and recall of the figure is dependent upon cognitive abilities such as planning, organization, and visual analysis. Consequently, when using the CFT, it may be erroneous to attribute poor recall of the figure solely to memory dysfunction particularly within a psychiatric population. The SCFT presents the stimuli in an organized, sequential manner. This modification is intended to facilitate encoding of the stimuli, increase the specificity of the test, and improve the interpretability of the results. An equivalent groups design is used to compare the CFT and the SCFT. Both group 1 (n=50) and group 2 (n=68) consist of psychiatric patients who had been referred for neuropsychological testing. In addition to the CFT for group 1 and the SCFT for group 2, a number of related neuropsychological tests are administered to all subjects. Results indicate that a more accurate copy of the figure is obtained on the SCFT than on the CFT but the differences between the immediate recall scores and the delayed recall scores only approached significance. Nevertheless, the percent savings score, which measures the quality and accuracy of the reproductions over time, is significantly higher on the SCFT. The SCFT appears to be a valid measure of nonverbal memory in a psychiatric population. These results are discussed in terms of their relevance to memory theory and to clinical practice.

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CHAPTER I

OVERVIEW

1.1 Introduction

This chapter provides an overview of the dissertation. It begins with a statement of the problem and its significance. A brief discussion of the historical development of memory theory follows emphasizing the information processing and general processing views of memory. Finally, the purpose, method, scope, and plan of the dissertation are presented.

1.2 Statement of the Problem

The lack of specificity of tests which assess memory functioning is a recent complaint found in the literature (Loring & Papanicolaou, 1987). The concern is that numerous cognitive operations may be required to successfully complete a task which will subsequently be used to make judgments about a specific cognitive operation such as non-verbal memory functioning. Psychologists are encouraged to consider the construct validity of the tests they employ in order to avoid making erroneous conclusions.

The present investigation examines the assessment of memory for newly learned non-verbal material which is chief among the functions considered most sensitive to pathological processes (Anastasi, 1988). At present, a widely used instrument to assess this important function is the Benton Visual Retention Test (BVRT). However, the test has a major drawback in that it is susceptible to proactive interference resulting from consecutive presentations of geometric shapes for recall. The BVRT also lacks in specificity since it involves both visual and verbal conceptualizations.

A second commonly used test to assess non-verbal memory is the Rey-Osterrieth Complex Figure test (CFT). This test is a neuropsychological test which is useful in differentiating perceptual defects and constructional disabilities from memory dysfunction (Lezak, 1983). Because of the complexity of the figure, it is particularly well-suited to assess non-verbal memory which approximates abilities required to function in a complex world. In addition, its visual complexity precludes the use of verbal labels as an encoding strategy resulting in a more valid measure of non-verbal memory. In contrast to the BVRT, the CFT is not susceptible to the effects of interference since the entire figure is learned once.

Unfortunately, the CFT, in its present form, has a major weakness. Successful copying and recall of the figure requires organization and planning which are abilities typically associated with the frontal lobe. The inability to plan and organize behaviour leads to the production of figures with missing or transformed elements and to perseveration. These errors may be erroneously attributed to memory dysfunction which is a cognitive ability largely associated with temporal lobe functioning. Correct diagnosis is essential to ensure appropriate remediation. Pillon (1981) found that patients with frontal lobe damage could not program an approach to copying the figure resulting in poor encoding of the stimulus. When provided with a strategy to guide their approach to the copy task, the patients with frontal lobe damage improved markedly. Altering the presentation of the task in this manner consequently improved its specifity resulting in more accurate interpretation of results.

The purpose of the present investigation was to determine if a modified version of the Rey-Osterrieth Complex Figure test, which eliminated the need for planning and organization, would be a more valid measure of non-verbal memory than its original version. The presentation of the test was altered in such a manner that organizing a strategy for encoding the figure was not required by the subject. Encoding of the stimulus became the major cognitive task to be performed by the subject.

The modification of the CFT was expected to produce a stronger memory trace since the formation of associations between components of the figure was facilitated. According to the depth of processing view (Craik & Lockhart, 1972), deeper encodings should result from the formation of associations. In order to place the processing view of memory in context, a brief historical overview of memory theories follows.

1.3 Historical Overview of Memory

1.3.1 Introduction

For several decades, the theory of associationism provided the most well-developed view of human memory functioning. It utilized the concepts of stimulus-response to explain memory as a sequence of events which became associated when they occurred together in time (Anderson & Bower, 1973). By the 1950s, the cognitive approach to memory functioning provided a serious challenge to the dominant view of associationism. Cognitive psychology, the study of thinking and knowledge, concerned itself with both memory processes and structures. Structural theories focused on questions about the nature of memory storage and how this information was represented and organized in the brain. Theories emphasizing processes attempted to describe the mental activities humans perform to put information into memory and later retrieve it. The dominant memory model which focuses on structures is called the information processing model (Atkinson & Shiffrin, 1968) while the general processing model (Craik & Lockhart, 1972) focuses on memory processes.

1.3.2. Memory as an Information Processing System

The dominant model of memory found in the literature in recent years is the information processing model (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965) which is based on three basic assumptions. It assumes that individuals are active participants in the encoding and retrieval processes, that patterns of responses can be analyzed and that information flow can be traced through several hypothetical stages. These stages include sensory memory, short-term primary memory, and long-term secondary memory viewed as a more permanent store of information (Poon, 1985).

Sensory memory occurs at a very early stage of memory processing where new information is initially registered. This very brief storage period is referred to as iconic memory in the visual system and as echoic memory in the auditory system (Neisser, 1967). Limited research is available on echoic memory and, to date, the slightly greater research on iconic memory is showing that it is relatively unaffected throughout a lifetime (Walsh & Prasse, 1980).

Short-term memory is a temporary store with limited capacity which plays an important role in the control and assimilation of information (Craik, 1977). At this stage of processing, the information is actively being used and when it is stored enters long-term memory. Long-term memory is conceptualized as an unlimited, permanent store of newly acquired information (Poon, 1985). The research on short-term memory has shown that it is affected only slightly by increasing age

(Poon & Fozard, 1980) and the only significant change observed is in the speed of recall of recently presented items. Conversely, research on long-term memory has demonstrated considerable changes especially in the age group beginning at 70 years (Read, 1987).

1.3.3 General Processing View of Memory

The general processing view of memory has been largely developed by Craik (1984). From this perspective, memory is understood in terms of encoding processes, retrieval processes, and their interactions. The encoding process involves the interpretation of a stimulus pattern in terms of qualitatively different types of past experience and in terms of innate analyzing procedures. Thus an event can be analyzed in terms of its sensory qualities (surface processing), and/or in terms of its meaning and significance in various different situations (semantic processing). The latter requires greater processing but both are necessary in relating to the environment. Memory of an event will reflect those analyses that have been performed at the time of encoding. The event will be remembered provided that some well organized body of past experience is brought to bear on the event and that the resulting analysis is somewhat different from the highly practised and routine procedures (Craik, 1984). Therefore the criteria for remembering are that the event be meaningful yet distinctive.

From the perspective of the general processing model, retrieval processes are identical to encoding processes but vary qualitatively, reflecting a mixture of surface and semantic processing. Retrieval is seen as a reinstatement of the initial encoding operations and not as a search for a specific memory trace. The system, in effect, re-organizes the original event (Craik, 1984). Remembering is facilitated to the extent that the aspects of the present environment induce the appropriate processing operations. Three types of remembering have been distinguished: recognition, cued recall, and free recall. Free recall is the most difficult since the system must reinstate the appropriate operations with minimal help from the environment and rely on general knowledge. In the present study, free recall of newly acquired nonverbal information was assessed.

1.4 Significance of the Dissertation

Evaluating the construct validity of the Rey-Osterrieth Complex Figure Test (CFT) and a modified version of the test called the Sequential Complex Figure Test (SCFT) by the writer, was the major objective of the present study. Since poor performance on the CFT could be attributed to dysfunction of brain regions typically associated with memory such as the medial temporal lobes or diencephalon, or to frontal and pre-frontal regions associated with planning and organizational abilities, the test's usefulness was limited in a psychiatric setting. Attentional deficits during the copy phase could also result in poor performance on the test, making accurate diagnoses difficult. By altering the test in such a manner that organizational abilities at the copy phase were not required, deficits could be more accurately attributed to dysfunction in the memory related regions of the brain. In addition, the test becomes a more specific measure of cognitive functioning and consequently, a more valuable diagnostic tool.

Assisting individuals who suffer from memory deficits due to improper encoding, as seen in various neurodegenetive diseases such as Alzheimer's disease or multiple sclerosis, is a potential contribution of the present study. Developing appropriate compensatory strategies could improve memory functioning by ensuring that stimuli are processed more effectively. Environmental modifications could be devised which facilitate the encoding process for those whose deficits are truly mnemonic while deficits involving other cognitive functions could be treated accordingly. Greater specificity of the assessment instrument could provide direction in the development and use of remediation strategies.

1.5 Purpose of the Study

As new results are obtained from research and new theories are developed, it is imperative that instruments used in the assessment of cognitive functioning be regularly evaluated and if need be, revised or rejected. The specific purpose of the present investigation was to evaluate and compare the efficacy of the Complex Figure Test and a modified version of the test in assessing non-verbal memory functioning of patients in a psychiatric setting. The modification of the test, which was called the Sequential Geometric Design test by Read (1987) and called the Sequential Complex Figure Test (SCFT) in the present study for the sake of continuity, is based on work done by L'Hermitte, Derouesne, and Signoret (1972).

Although the test in its original form is a good measure of visuospatial ability and nonverbal memory in young adults (Lezak, 1983), many psychiatric patients find this complex geometric design too difficult to draw accurately. The poor initial drawing of the figure results in poor encoding which in turn leads to poor recall of the figure (Craik, 1984). The modification was designed to improve encoding which, according to the theory of encoding specificity (Tulving & Tompson, 1973; Wiseman & Tulving, 1976), results in improved immediate and delayed recall of the stimulus figure. Impairments on the test can then be more readily attributed to true memory impairments per se rather than to improper encoding since the strategies used at encoding are identical to those used in retrieval. Consequently, the validity and reliability of the Complex Figure Test in assessing nonverbal memory is improved.

1.6 Synopsis of the Method of the Dissertation

The method of investigation used in this study was an equivalent groups design. Two experimental groups were formed from patients admitted to Alberta Hospital, Edmonton who were referred for neuropsychological investigation. The first group of patients was tested with the original Rey-Osterrieth Complex Figure Test and the second group was tested using the modified version. Eighteen individual components make up the original Rey-Osterrieth figure. In the modified version, an eighteen page test booklet is used to present these components, one at a time. The first page of the booklet shows the black outline of the first component. The second page shows the same component printed in dashed lines with an additional component printed in solid black lines. Each subsequent page contains the components that have already been presented as dashed lines, with the new component shown in solid lines, until the complete figure is revealed on the final page. Both presentations are followed by immediate and delayed recall of the stimulus figure.

In addition to the Complex Figure Test (CFT), all subjects were tested on a battery of neuropsychological tests which included the Benton Visual Retention Test (BVRT) used for comparative reasons. If subjects performed poorly on the CFT or the SCFT, they were also expected to perform poorly on other measures of nonverbal memory. Contrarily, performance on tests which assess frontal lobe functions was expected to be independent of the results obtained from memory measures. These findings were used to evaluate the validity of the CFT and the

SCFT. Analysis of variance procedures were used to compare the results from both groups. Comparisons were made between groups and between sexes on data from five neuropsychological tests and the Wechsler Adult Intelligence Scale-Revised.

The subjects for the present study included a mixture of forensic and clinical patients who were suspected of some form of brain dysfunction. They represent consecutive referrals to the Neuropsychological department of Alberta Hospital and only those patients who completed a full battery of tests were included. The original form of the Complex figure test was administered to patients beginning in January of 1987 while the modified version was introduced in August of 1988.

The function of this study was not to determine if performance on the non-verbal memory task is associated with organic brain dysfunction but to demonstrate that within a clinical population, test results may be affected by unexpected factors such as improper encoding procedures.

1.7 Hypotheses

The present study was designed to test the following null hypotheses:

1. Significant differences in memory scores would not be obtained by altering the method of data presentation.

2. Both the Complex Figure test and its modification, the Sequential Complex Figure Test would assess the same functions and would correlate with other

nonverbal memory tests.

3. No gender differences would be observed on either form of the test.

The results obtained were used to answer several questions:

1) Are there significant differences in the copy, immediate recall and delayed recall scores between the Complex Figure Test and the Sequential Complex Figure Test?

2) Are both forms of the test assessing the same functions?

3) Are retrieval processes affected by encoding processes?

1.8 Scope of the Dissertation

It is the aim of this investigation to examine nonverbal memory functioning in a psychiatric setting in an effort to improve the assessment of this important function. Other cognitive functions were assessed using instruments selected because of their well-established norms and their popularity in the psychological community. To review all of the areas pertaining to memory and its assessment is not possible, consequently certain areas have been omitted. These include the development of memory in humans, psychobiological determinants of memory failures, memory functioning in the aged and assessment instruments specifically designed as verbal memory tests.

Because of the time factor, the number of tests used in the investigation had to be limited. In addition, because of the small percentage of subjects falling outside the age group of 15 to 50 years, subjects outside this range were eliminated.

1.9 Plan of the Dissertation

The present dissertation was divided into six chapters. Chapter II contains a review of the literature on memory theory while a review of the neuropsychological studies on memory is provided in Chapter III. The design of the study is presented in Chapter IV including subject description, assessment variables, procedures used and methods of data analysis. The results of the investigation are described in Chapter V and Chapter VI contains a general discussion of the experimental and clinical implications of the study. Future lines of inquiry into research on non-verbal memory are also proposed.

Chapter II

THEORETICAL REVIEW OF MEMORY

2.1 Synopsis of the Chapter

The present chapter begins with an examination of the theoretical approaches which have contributed most to the study of memory. This was followed by an examination of the structural model of memory including the sensory, short-term, and long-term stores. Finally, the processing model of memory and the amendments made to the theory in recent years are discussed.

2.2 Theoretical Approaches to Memory

Several theories concerning human memory have been proposed but for the purpose of the present discussion, these will be categorized under two broad headings: associationism and cognitive psychology. Although the boundaries between these two approaches are not easily drawn, they do appear to represent very different orientations.

2.2.1 Associationism

Aristotle is usually given credit for first articulating the laws of association which were later elaborated by the British Empiricist philosophers (Anderson & Bower, 1973). The group of philosophers usually classified as associationist included among others, Locke, Berkeley, Hume, James Mill, and John Stuart Mill. Although their views differed in many major aspects, their collective influence and common basic assumptions had a major impact on the later study of memory.

The majority of these philosophers argued for a theory of knowledge known as empiricism. Empiricism is defined as the philosophical view that all knowledge is directly derived or inferred from sense data (Angeles, 1981). From this perspective, the content of mental life was thought to be derived entirely from experience and one's reflections on that experience (Wingfield & Byrnes, 1981). Sensations were the structural elements of mental life and these were linked together by the laws of association. That is, sensations which occurred contiguously would become associated. Contiguity would determine which sensations would become associated while the frequency with which the sensations occurred together and the vividness of the sensations determined the strength of the associations.

The impact of the associationists' explanations of mental life has had a lasting effect on psychology. It lead to the elevation of learning and memory to one of the major topics of study in the developing science of psychology. The association of sensations gave way in later theories to the association of stimulus and response (S and R). The concepts of vividness and frequency were replaced with intensity and practice and the complexity of any idea was simply the result of the addition of elements to form a larger number of interconnected associations. The sequential dependencies between words became the primary problem in the analysis of human memory. All problems of remembering and recalling within this framework, were reduced to problems in the acquisition, retention, recognition and retrieval of associations. This well-developed and powerful view of memory has permeated research in this field for numerous decades (Winfield & Byrnes, 1981). It is only within recent times that associationism has received a serious challenge from the cognitive approach to human functioning. An excellent account of the associationists movement can be found in Anderson and Bower (1973).

2.2.2 Cognitive Psychology

Beginning in the late 1960s, the term cognitive psychology began to be used to describe the experimental psychology of how people acquire, store, manipulate and use information (Neisser, 1967). In short, it became known as the psychology of knowing.

Cognitive psychology was influenced by the early Gestalt school of psychologists who believed that learning could not be described merely as the formation of associations among elements. Instead, perception, memory and thinking were thought to form a dynamically organized system where new information is not just added; it also modifies the organization of the system (Koffka, 1935). New information could also be altered to fit the organization of the system in which it had introduced some change. The important contribution of this approach was the emphasis on an organized system and the idea that new and old information could have reciprocal effects on one another.

The view that new information is assimilated in the context of existing systems of knowledge which can be reorganized in the light of this information led many to see an analogy between the processing of information by machines and by people. The rapid development of computers following World War II which were capable of storing and retrieving considerable amounts of information at high speeds provided a precise manner of talking about how information might be handled by human beings. The adoption of this analogy by cognitive psychologists lead to the information processing model of memory which is commonly held at the present time (Stern, 1985).

2.2.3 Memory as an Information Processing System

From the information processing system point of view, mental processes function much like a computer program. A program manipulates data in a series of stages or levels. It first selects appropriate information and then uses this information to perform a sequence of operations which require a segment of time. Viewing memory from this framework has permitted cognitive psychologists to generate experiments which measure the amount of time required to perform different memory activities and determine how different stages of processing might be arranged. It has also permitted the analysis of how one level of activity might affect others.

Like the computer, the human memory system must store information and appears to have a number of memory stores. These human memory stores apparently differ according to the permanence of the information that they maintain. A second similarity between the computer and human memory is that both are processors of information. In the human information processing system, memory consists of a combination of structures and operations that are performed on information as it flows along specified pathways (Atkinson & Shiffrin, 1968). According to this model, when information from the environment first enters the system it is stored briefly in a sensory store. The information may then be passed to the short-term store or it may simply be lost. Information that enters the short-term store may be maintained as long as the process of rehearsal is performed. This is analogous to the temporary memory store in the computer, sometimes referred to as the working memory, which is used to hold information that is being manipulated by a computer program. Eventually, processed information is transferred to a permanent or long-term store and retrieved when needed.

The information processing model of memory has generated mounds of research and numerous questions concerning human memory. One way of distinguishing the different kinds of questions about memory is to separate those which concern processes from those which concern memory structures. Memory processes refer to the mental activities involved in acquisition and recall while memory structure refers to the manner of storage of the information, its duration and its organization (Wingfield & Byrnes, 1981). Both processes and structures must be examined in greater detail to obtain a greater understanding of this complex mental activity.

2.3 A Structural Model of Memory

Beginning with theorists such as Broadbent (1958) and culminating in the work of Atkinson and Shiffrin (1968), psychologists have attempted to produce a pictorial representation of the memory system which would depict those component operations which must logically be

involved in memory processing. Specifying the order of these operations also appeared to be important. This desire lead to the typical representation of memory as a flow chart containing boxes and arrows commonly used in describing computer programs. Each of the boxes represented some structure in the system which would hold information as it was processed and eventually stored. In addition to the structures, there were also control processes. This sequential linear model remained the dominant view of memory for over 20 years and helped to organize a confusing mass of data and suggested fruitful lines of research (Lachman, Mistler-Lachman, & Butterfield, 1979).

2.3.1 Sensory Memory

The first stage of the memory processing system is the so-called "sensory memory". This particular memory store preserves incoming stimulation from the senses for a brief period of time to permit processing. It has several characteristics which distinguish it from regular memory. First, its only content is a record of the sensory effects of the stimulus which is a merely a representation of the physical characteristics of the stimulus (Wingfield & Byrnes, 1981). Second, it has a relatively large capacity of which only a small portion produces any lasting effect on later memory. Third, the duration is very brief. Visual sensory memory lasts for less than a second while auditory memory might persist for a few seconds (Klatsky, 1975).

Through the visual sensory memory system, information is extracted from the environment in a succession of rapid, discrete fixations. Sperling (1960, 1963, 1967) developed techniques to determine how much information could be derived from a single glance. Sperling presented letters of the alphabet to subjects for .05 seconds in a tachistoscope and found that if the number of letters presented were less than four, subjects could easily report the whole matrix. Regardless of the total number of items presented, subjects could never report more than four or five letters correctly although they were aware that they had seen more letters than they could report. Sperling speculated that the initial visual store of information had a very large capacity however the process of identifying and classifying the stimuli would be incomplete when the representation disappeared. To test this hypothesis, Sperling developed the partial report technique to replace the whole report technique he had been using. Rather than require the subject to attempt a complete report of the information in the visual memory which was a time consuming process, he had subjects recall only a specified portion of the total information displayed.

In one version of Sperling's partial report procedure (Sperling, 1960), subjects were presented with a three by three matrix of nine letters for .05 seconds. One group of subjects was asked to recall as many letters as they could and a second group were told to expect one of three tones immediately following the flash of letters. A high tone was a signal to report just the top row, a medium tone indicated the second row while a low tone would signal recall of just the bottom row. The average recall accuracy of the whole report format was 4.3 letters and never improved much beyond 4.5 letters for any subject. In the partial report format, subjects were able to recall any one line with 90% accuracy. Sperling concluded that the limit of 4 or 5 letters which subjects ordinarily recall is not a limit on the amount of visual information seen at a glance but rather on the rate of information transfer and storage in later parts of the memory system.

Sperling originally called this visual sensory memory a "visual image" but the term became confused with afterimages and mental images. Neisser (1967) dubbed the visual sensory memory as "iconic memory" in an attempt to clarify this confusion and numerous studies were undertaken to determine the characteristics of the iconic memory. Mackworth (1963) discovered that iconic memory is sensitive to the physical characteristics of the stimulus such as the brightness of the visual field. If the visual field following the exposure of the stimulus is dark, the duration of the usable sensory image is longer than if the postexposure field is light. This characteristic distinguishes iconic memory from other forms of memory. A number of researchers (Averbach & Coriell, 1961; Briggs & Kinsbourne, 1972; Efron, 1973; Haber & Standing, 1970; McCloskey & Watkins, 1978) have estimated the duration of iconic memory to be approximately 1/4 of a second. These studies also appear to demonstrate that iconic memory is a brief form of storage that has a capacity much larger than the forms of storage that follow it. Another characteristic of iconic memory is that the information stored is precategorical (Turvey & Kravetz, 1970; Banks & Barber, 1977). That is, the processes which identify items and assign them some classification, have not yet occurred. Finally, the registration of information in iconic memory takes place automatically, without requiring attention or effort unlike information which is transferred to short-term memory (Chow & Murdock, 1975).

The auditory counterpart to iconic memory is echoic memory (Neisser, 1967).

As with the visual sensory memory, arguments for the existence of a temporary storage of unattended auditory information are compelling. One example is the "cocktail party" phenomena where one's attention can be directed to a single speaker in a room full of speakers without attending to other conversations but notice at once if one's name is mentioned from across the room.

Moray, Bates, and Barnett (1965) explored this phenomena using a procedure analogous to Sperling's partial report technique. Subjects in their experiment heard lists of spoken letters simultaneously from four loudspeakers located in different areas in a room. When asked to report all the information from the four locations, subjects only reported a very small portion. When a visual light cue was used to signal one of the four loudspeakers immediately following the auditory presentation, recall accuracy was excellent. Since the visual cue indicating which message to report occurred only after all messages were presented, it is reasonable to believe that auditory memory for information from all locations must exist. That is, an echoic memory whose capacity exceeds the limited capacity of ordinary memory, must exist.

The duration of echoic memory has been estimated to be between 2 and 6.4 seconds, depending on the study (Crowder & Raeburn,1970; Morton & Holloway, 1970; Routh & Mayes, 1974). Wingfield and Byrnes (1981, p. 179) estimate the duration of echoic memory to be about 2 seconds based on the average of the research findings. The difficulty in measuring the duration accurately arises because of evidence demonstrating processing operations which begins on the acoustic trace. Since echoic memory is defined as a precategorical acoustic store (Crowder & Mortan, 1969), a clear demarcation indicating the beginning of short-term processing might be observed. This clear-cut view advocated by early structural approaches to the study of memory has not been substantiated through research. Studies on echoic memory have produced evidence suggesting that it consists of a precategorical representation of all auditory inputs which is formed automatically, but fades rapidly if not coded by selective attention to it (Treisman, 1964; Glucksberg & Cowan; 1970).

According to the "process" model of memory, discrepancies about the duration of sensory memory, both iconic and echoic, can be explained using a levels of processing approach. This model suggests that stimuli undergo a continuous transformation of coding formats rather than proceed through a sequence of distinct stores. Discrepant experimental results occur because the levels of processing being tapped are not consistent (Craik & Lockhart, 1972; Schneider & Shiffrin, 1977). This view implies a progression of coding formats ranging from simple sensory persistence through increasingly abstract representations. Attention, seen as an operation which is necessary to select information for deeper processing, utilizes resources from a limited pool to form certain types of memory codes. The allocation of attentional resources determines the kinds of memories and knowledge which result from a particular experience. According to this model, sensory memory is formed automatically and the distinction between pre- and post-categorical memory is the degree of attentional resources which are required. That is, further processing activity on the part of the subject is not automatic but rather a deliberate action.

2.3.2 Short-Term Memory

According to the structural view of memory processing, two separate information stores exist beyond sensory memory: short-term memory and long-term memory. The role of short-term memory in this system is seen as a temporary holding area for recent information selected from sensory memory while it awaits transfer to long-term memory. This distinction between short-term and long-term memory has come to be known as the "duplex theory" of memory (Wingfield & Byrnes, 1981). Atkinson and Shiffrin (1968) proposed that a distinction between control processes and structural components be applied to this two-memory framework. The control processes represent a decision on the part of the subject to operate the memory system in a particular way while the structural components form the system. Short-term memory according to this view, is a structure and the following discussion will focus on the capacity of this store, its content, and the manner in which information is either lost or transferred to long-term memory.

The existence of short-term memory (STM) can be traced back to two separate but identical studies which occurred simultaneously in different parts of the world. Both Brown (1958) in England and the Petersons (1959) from the United States demonstrated that information is lost from STM in the space of seconds if it is not rehearsed. These results were surprising at the time, since it was believed that information could be lost only if interference of the associations between stimulus and response occurred. The passage of time was not an issue. These researchers are usually given credit for designing the distracter procedures used in the experiments on decay versus interference in STM and the label "Brown-Peterson paradigm" is often used to describe the experimental model (Klatsky, 1975; p.90).

2.3.3 Forgetting in Short-term Memory

The results of the Petersons'(1959) experiment is a good example of how unrehearsed information decays rapidly in STM. Subjects in this experiment heard a three-consonant trigram such as DNP presented at a rate of one consonant per half second. Immediately following this, the subject heard a three-digit number and was required to count backwards immediately from that number by threes to the beat of a metronome. The counting period varied from 3 seconds to 18 seconds and this period of time was referred to as the retention interval. The backward counting was intended as a distracter task which would prevent rehearsal of the trigram.

Since the distracter task used numbers while the retention material was letters, retroactive interference should not occur. Memory loss could therefore be attributed to the passage of time alone. After 3 seconds, subjects could recall all three consonants 80% of the time but after 18 seconds, the frequency of correct responses fell to 10%. The results indicated that passive decay of unrehearsed information occurred rapidly in STM and this was not due to the results of associative interference. These findings sparked research on the mechanisms of forgetting in both STM and long-term memory (LTM) and led to the development of several structural theories explaining how information was transferred from one memory store to another and how it was lost (Atkinson & Shiffrin, 1968).

Several subsequent experiments found that the distracter tasks in Brown-Peterson type studies can actually be interfering. Both Reitman (1971) and Shiffrin (1973) found that distracter tasks involving verbal skills were more likely to disrupt retention of verbal forms than non-verbal tasks such as signal detection. Watkins, Watkins, Craik, and Mazuryk (1973) showed that difficult non-verbal tasks could also produce short-term forgetting. These studies suggest that two aspects of distracter tasks may determine the extent to which forgetting is produced in STM. One is the degree to which the distracter material and the to-be-remembered material are the same. The second is the general difficulty of the distracter task. Other studies which support this latter finding include Posner and Konick (1966) and Posner and Rossman (1965). Evidence on forgetting in STM seems to call for a theory that includes both passive decay and interference. The rapid decay of information in STM does occur without rehearsal but interference in STM can also be demonstrated by using similar distracter tasks or tasks which require greater processing capacity.

2.3.4 The Capacity of Short-term Memory

The amount of information which could be held by the STM at any one time was first discussed and elaborated by Miller (1956). After reviewing the substantial literature on memory span, Miller proposed that the capacity of immediate memory span is seven units of information plus or minus two. Miller used the term "chunks" for these subjectively defined units based on prior learning and pointed out that the span of immediate memory remains almost the same despite changes in the size of the chunks. The ability to recode single stimuli into larger units is called chunking (Klatzky, 1975). As an example, the letters CATBARTOYSIP can be easily recalled when broken down into CAT/BAR/TOY/SIP.

As researchers began to examine the capacity of STM in greater detail, it became obvious that immediate memory span reflects the operation of more than one storage component (Watkins, 1974). A short term store can take advantage of relationships between items only if associative connections have already been established (Baddeley, 1976, pp. 134-135). Size of memory span reflects in part previous learning such as the spelling of words or arithmetical relationships between numbers and therefore it would be erroneous to equate STM capacity with immediate memory span. Craik (1971) concluded that the true capacity of the short-term memory store is between 2.5 and 3.5 items suggesting that the difference between his estimate and Miller's is explained by the contribution of long-term memory to ordinary memory span data.

2.3.5 Retrieval from Short-term Memory

The duplex model of memory postulates that the retrieval strategies in STM and LTM are significantly different (Wingfield & Byrnes, 1981, p. 248). While long-term memory is viewed as a vast store of meaningfully related concepts, short-term memory, with its limited capacity, maintains its content only through rehearsal. Immediate testing reveals only that information is either retained or not but reveals nothing about the recall strategies used. Seminal research on this subject was done by Sternberg (1966). Sternberg developed an ingenious method to study retrieval from STM, using reaction times to infer about invisible mental abilities. He required subjects to learn a list of numbers which was immediately followed by a probe number. The subject had to indicate, with a yes or no, whether the probe number had been included in the list of numbers to memorize. Since the list of numbers to be learned were relatively short, accuracy was very high but the important variable in Sternberg's study was the speed of response. In order to arrive at a response, subjects had to perform three operations: identify the probe, scan the memory set, and make a decision by pressing a yes or no lever. Sternberg hypothesized that no matter how long the memory set, operations one and three would not vary in length. Only the scanning operation which would vary according to the length of the memory set would have any effect on response time. Scanning for retrieval became the operation to be investigated.

Three logical possibilities existed which would explain the relationship between scanning, reaction time, and size of the memory set. First, when the probe appears, a subject might examine all the digits simultaneously or in parallel and therefore reaction time would be unaffected by the length of the memory set. Second, subjects might compare the probe to each digit in the memory set until a match was found. The search would then immediately terminate. The number of digits to be scanned would affect reaction time. This type of processing was called the "serial self-terminating search" by Sternberg. A third possibility was that a serial exhaustive search would occur where the subject would scan the full set of numbers before making a decision. Therefore, the more digits in the set, the longer the reaction time. The relationship between length of set and reaction time should remain the same whether the response was yes or no since the search is exhaustive.

The results of Sternberg's study suggest the scanning method used in short-term memory must be the "serial exhaustive search" no matter how intuitively unlikely this finding may be. That is, even when the probe is located early in the memory set, scanning of the entire set occurs before a decision is reached. Sternberg (1966) arrived at this conclusion because he observed that not only did reaction times increase with size of memory set but "yes" responses increased at exactly the same rate as "no" responses. Since the "no" response is necessarily exhaustive, the "yes" response must involve the same process. Sternberg postulated that scanning is likely a very rapid process while decision making a slow one and efficiency would be reduced if a decision were required after each item. Sternberg's results were replicated in a other studies (Chase & Calfee, 1969; Wingfield, 1973) and they appeared to be robust whether the memory digits were presented one at a time or all at once, or whether sets were presented visually or auditorially. Even when hospitalized schizophrenics or alcoholics were used as subjects, the same evidence for serial exhaustive searching in STM was found (Sternberg,1975).

As memory scanning research continued, it began to appear that serial exhaustive scanning in STM may be limited only to situations where the presence or absence of a specific item is to be determined. In situations where an item must be recalled from memory, evidence for a serial self-terminating search is available (Wingfield & Bolt, 1970). In addition, other researchers attempted to explain retrieval operations in STM from a parallel processing view, stating that if the system has only limited resources and more resources are required for the parallel processing of longer lists, it would account for the increase in reaction time. Further discussion of this controversy can be found in Corcoran (1971) and Wingfield (1973). The importance of these studies is that they have shown how reaction times can be used to make inferences about short-term retrieval strategies. In addition, they provided support for the notion that STM has a limited capacity and holds items temporarily through active rehearsal until they are either forgotten or transferred to long-term memory.

2.3.6 The Content of Short-term Memory

According to the duplex theory, the character of the codes used in STM was verbal or acoustic and not semantic as in long-term retention. Conrad (1963) was one of the first to propose that the memory codes in the two stores were different. He found that when letters of the alphabet were presented visually to subjects, acoustic rather than visual errors occurred. By examining the confusion errors people made, Conrad concluded that the STM contained only representations of sound while meaning and relationships were coded in LTM.

Further support for the dichotomy between STM and LTM with presumed acoustic coding in one and semantic coding in the other came from studies done by

Sachs (1967), Baddeley and Dale (1966) and Kintsch and Buschke (1969). For example, in the latter study, subjects saw 16 typed words presented one at a time and were asked to read these aloud and remember the items. The list was followed by a seventeenth item which was a repetition of one of the 16 words and the subject had to name the word that followed this word in the list. Some of the lists had eight synonym pairs while some contained words that sounded alike. The results showed that similarity of meaning produced confusion only when subjects tried to recall items presented early in the list which were presumably in long-term storage.

Subsequent work on memory codes has raised many questions about the semantic and acoustic coding described by the duplex theory. Craik and Kirsner (1974), for example demonstrated that subjects can remember a speaker's voice long after it is first heard. Visual storage in STM has also been quite well established. The best known of these studies was done by Cooper and Shepard (1973) at Stanford University. They presented a series of two letters to subjects where the first letter was always a normal letter from the alphabet. The second letter was either the normal letter previously presented or a mirror image of the letter. The second presentation of the letter was rotated 60, 120, 180, 240 or 300 degrees. The subject had to decide as quickly as possible if the second letter presented was normal or reversed, mirror image of the original. The results implied that subjects could mentally rotate the letters to the vertical position, either right or left, in order to make a decision and the time required to do so was measurable. They concluded that performing this task required a short-term visual code which could be mentally manipulated.

The most extensive work on the processing of visual images was done by Paivio (1969) who reported that lists of visualizable nouns are generally easier to remember than more abstract, difficult-to-visualize words such as trust. This occurs even when words are matched for frequency of usage in the language (Paivio, 1971). These studies provided support for the idea of visual imagery as a viable form of memory representation but Anderson and Bower (1973) proposed that imagery instructions might operate to conceptually organize information in memory and thus lead to deeper and more elaborate memory codes. As will be discussed under the "Levels of Processing Model" of memory, deeper, more elaborate coding may lead to better retention. Most disturbing to Paivio's interpretations of visual imagery in memory is the finding that subjects blind from birth are assisted in retaining words when instructed to form visual images of the words (Jonides, Kahn, & Rozin, 1975).

Based on his findings, Paivio (1971) proposed a dual-code model of memory representation which consisted of separate representational systems for verbal and visual information. Abstract words would be coded verbally while concrete words would be coded both visually and verbally thereby explaining the ease of recall of concrete words. However, many theorists feel that it is unlikely that people store picture-like images in memory (e.g. Intraub,1979; Pylyshyn, 1973; Norman & Rumelhart, 1975). These studies suggest that memory codes for visual stimuli are modality-free conceptualizations of an abstract nature which can be used to recreate visual perceptions. This is demonstrated by the errors often made in describing scenes from memory which include changes from the original and omission of details (Norman & Rumelhart, 1975). The errors observed in these studies are not consistent with those expected if one were looking at a faded or blurred picture.

2.3.7 Summary

The duplex view of memory proposes that short and long term memory are qualitatively different structures with fixed characteristics. The differences in these stores include:

1. rapid loss of memories in short-term memory while well learned information stored in long-term memory could persist for years;
2. limited capacity for immediate recall with apparent unlimited capacity in the permanent store;
3. acoustic representations of stimulus in short-term memory with semantic or associative representations in long-term memory;
4. decay is viewed as the reason unrehearsed material is lost in short-term memory while interference explains forgetting in long-term memory.

Numerous exceptions to the differences listed above has recently lead to doubts about the notion that an inflexible sequence of operations places information into structural stores. The emphasis appears to have shifted from storage structures to processing resources. Before the process view of memory is discussed, a brief review of long-term memory (LTM) is presented.

2.3.8 Long-term Memory

The present section on long-term memory includes a brief examination of the models developed to explain the structure of LTM, a discussion of how information in LTM is stored and lost and finally an overview of the process of retrieval.

2.3.9 Structural Models of LTM

Prior to presenting models of long-term memory, an important distinction proposed by Tulving (1972) must be mentioned. His work has had profound effects on memory research in the past fifteen years. Tulving proposed that LTM may in fact be two memory stores: episodic and semantic memory. These two stores can be distinguished by several dimensions. First, the nature of the information stored is different. Episodic memory is organized by time and space and is characterized in terms of perceptual descriptions such as colour and size. The organization in semantic memory is abstract and conceptual and it contains organized knowledge about words, their meanings and their relationships.

A second distinction is that it is possible in semantic memory to combine existing information to produce new knowledge while information from episodic memory can be retrieved only as it was stored. Information from semantic memory can be used to produce inferences from episodes but each time information is retrieved from episodic memory, more information is added to the content of that memory. Retrieval from semantic memory leaves it unaffected. Finally, episodic memory is highly susceptible to interference while semantic memory is affected much less by the introduction of new information (Tulving, 1972). Tulving's distinction is crucial since the proposed structural models of LTM are all models of semantic memory. This is so because in episodic memory, events are recorded as is, while information in semantic memory undergoes considerable processing.

The first model of semantic memory to be discussed is the Network Model (Collins & Quillian, 1969). This model is associative in nature but it is not merely a series of S-R associations such as fish-swim. The model organizes entries by semantic category. The main components of the Network Model are units which correspond to the concepts, pointers which are the connections between concepts and properties representing the features of the units. All units in this model are hierarchically organized so that rose and tulip are listed under the category of flowers and flowers under plants and so on. Units are stored along with their properties in the most economical manner. For example, has petals is stored with flowers and not with rose or tulip. The pointers are activated when the search for information is initiated. The pointers lead from one unit to the next proceeding upward and outward throughout the network.

Although the Network model has strengths, it also has major weaknesses. It overlooks the interaction between episodic and semantic memory for it is clear that our personal experiences form a large part of our concepts. It also neglects to describes the dynamics of retrieval strategies and lacks explanations on how inferences might be drawn from potential relationships (Wingfield & Byrnes, 1981).

A model which accounts for the interaction between episodic and semantic memory is called Human Associative Memory (HAM) created by Anderson and Bower (1973). In this model the long-term memory structure remains constant but the plans and strategies used to perform a task vary. The most important structural element of the HAM model is the proposition. The proposition is intended to be a nonlinguistic representation of relationships among concepts or ideas. Since the information in the structure is conceptual and abstract without any relationship to words, it is general enough to encode information about visual stimuli. When information is presented, the HAM system analyzes it and the results are represented in a tree-like structure. This structure is stored in temporary memory to verify it against existing information in LTM. If the information already exists, it will not be restored but if the information is new, the associations between concepts which make up the proposition will be transferred into LTM. This model is an association model which clearly describes different types of associations, unlike S-R theorists. It is also a hierarchical model which permits concepts to be embedded within one another. Unfortunately, the HAM model does not account for the inferences and deductions which, as Potts (1972) has demonstrated, can be stored in LTM.

A third model of LTM is the Semantic Features Model which attempts to account for some of the ambiguities in real memory performances related to category membership. For example, why is a whale not a fish? In the semantic features model, the meaning of a concept is represented by a list of its properties and descriptions, or features (Rips, Shoben & Smith, 1973). These features are ordered from the most important in identifying the concept to the least important. Judging the importance of the defining features is based on a person's knowledge and experience with a particular concept. Verification of information takes the form of comparing features lists belonging to the concepts involved. Concepts which share many features belong in the same category while few common features demonstrates a lack of relationship. Semantic relatedness avoids the problems of a hierarchical model by overruling logical relationships.

The models of semantic memory discussed thus far are the best-known examples of network models. The present discussion will not include an exhaustive presentation of LTM models since it is beyond the scope of this project but one more model will be discussed. This model is representative of the set models of semantic LTM and is called the set-theoretic approach (Meyer, 1970).

The set-theoretic approach assumes that semantic categories are represented in LTM as sets or collections of information. In verifying data from the environment subjects will compare sets to determine the extent of overlap. The degree of overlap enables the subject to support or disconfirm sentences in the form of "All Ss are P" or "Some Ss are P". According to Meyer (1970) such a model can account for category-size effects where the larger P is relative to S, the less they overlap and the longer it will take to find S. For example, it takes less time to determine if a canary is a bird than it does to determine if it is an animal. Unfortunately, the model does not account for irregularities such as the longer length of time required to determine if cat is a mammal versus cat is an animal when the set of mammal is a smaller set (Klatzky, 1975).

The discussion of the models of LTM is intended to demonstrate how researchers have attempted to account for the vast amounts of information stored in LTM. Penfield (1959) claimed that everything that was once stored in LTM is still there. This information appears to be stored in a very orderly fashion enabling us to retrieve information from LTM. Attempts to describe the regularities and the storage-formats of LTM used in processing astounding amounts of information has been an ongoing task amongst researchers. The next section of the present review will examine how information in LTM can be forgotten.

2.3.10 Forgetting in Long-term Memory

Forgetting is defined as what occurs when material that was once encoded, and is now sought but cannot be retrieved (Klatzky, 1975). At one time, decay in long-term memory was thought to be the cause of forgetting but the notion of autonomous decay processes has largely been discredited as an explanation for forgetting from LTM (Broadbent, 1958; McGeoch, 1932). The dominant view guiding research on forgetting is interference theory in one form or another. The essence of this theory is the detrimental effects of learning similar or related material (Wingfield & Byrnes, 1981). Two forms of interference have been proposed in the literature: retroactive interference (RI) or the detrimental effects of new learning on the recall of older learning and proactive interference (PI) or the detrimental effects of previous learning on the retention of recently learned material. Both of these forms of interference will be examined. It is important to mention that interference theories apply to forgetting in episodic memory since semantic knowledge is not so easily forgotten (Tulving, 1972).

Retroactive interference is a common experience, especially for students at the post-secondary level. The first few lectures in a statistics class, for example, may be relatively easy to follow but as more information is added, the recall of earlier material is made more difficult. Slamecka (1960) demonstrated this phenomenon in laboratory studies using verbal learning techniques. The results demonstrated that the more similar newly learned material is to previously learned material, the greater the retroactive interference. Also, the more practice the new material receives relative to old material the greater the retroactive interference effect.

In the studies on RI, it was observed that the control groups experienced some loss of information even when no interference occurred between learning and recall. Underwood (1957) reviewed the literature on retention studies and observed that subjects had often been subjected to numerous learning trials during the course of an experiment. Underwood plotted the results of 14 experiments on a graph and showed that the more lists subjects learned prior to the main experiment, the poorer the retention scores. From these observations developed the standard paradigm for the study of proactive interference (PI). In a typical PI experiment, subjects learned a list of paired associates to criterion then learned a second list. The control group learned only the second list. Comparisons showed the existence of detrimental effects of prior learning on the acquisition of new material. The degree of PI increases with the number of similar lists learned and is dependent on the relative amounts of practice given to the old versus new learning (Slamecka, 1961; Underwood, 1957).

A major criticism of the experiments on RI and PI is that the approach to learning was purely rote and the material to be learned consisted of meaningless unrelated words. These conditions tended to exaggerate the effects of RI and PI. In typical learning, the context is important to the level of recall. Environmental cues aid in distinguishing one body of information from another and recall is improved if testing is conducted in the same environment in which learning originally took place (Dallet & Wilcox, 1968; Godden & Baddeley, 1975).

2.3.11 Retention in Long-term Memory

The three most commonly used measures of retention in LTM are recognition, savings, and recall. The goal of these measures is to detect the residue in memory of prior learning. A survey of the literature on these measures is beyond the scope of the present study but Kausler (1974) has provided an exhaustive review of these procedures. Simple definitions of recognition and savings are presented in this section with some elaboration on the organization in free recall.

Recognition testing is similar to a multiple-choice examination, i.e., the correct answer is presented along with several alternative answers. Two forms of recognition memory are typically used: either several alternatives are presented and the subject must select the correct one or one item is presented and the subject is asked whether the item was included in the newly learned material or not. Recognition memory is the most sensitive measure of retention and produces higher scores than recall because it restricts the size of the set alternatives (Davis, Sutherland & Judd, 1961). To demonstrate the power of recognition memory, Shepard (1967) gave subjects 540 words in rapid sequence and later presented them for recognition along with a set of distracter items. Shepard recorded an average of 88% correct after a single exposure. This percentage was also recorded by subjects who had been presented with a list of 1224 sentences indicated that 1077 sentences were recognized after one presentation.

The savings measure requires subjects to relearn a list after some elapsed time (Klatzky, 1975). Memory of the initial presentation permits the same material to be learned more easily the second time around. The results of this form of testing are usually presented as a savings score based on the difference between the time or trials required for initial learning and the time or trials required on a subsequent occasion.

The method of recall measures retention by having subjects remember items either in order (serial recall), without regard to order (free recall) or in response to a cue (cued recall). Each of these measures has been used to examine different kinds of questions about memory. For the purposes of the present study, the organization of free recall will be examined in greater depth.

In order to simplify recall of personal experiences, it has been demonstrated that the higher the association values between items, the more likely they are to be recalled together (Jenkins, Mink, & Russell, 1958; Deese, 1961). To demonstrate this, the separate words from word pairs, which are known to be strong associates such as mother-father and north-south, are presented in a scrambled manner to appear as a random arrangement. On recall testing, associated words were grouped together especially for the pairs with stronger associations. Recall performance of such lists appears to be directly related to their association strength demonstrating associative clustering in free recall.

Category clustering has also been demonstrated in free recall. Pollio, Richards, and Lucas (1969) provided subjects with a scrambled list of words which each fell into one of five categories. They demonstrated that not only did subjects recall category clusters but each cluster was followed by a noticeable delay before the production of the next category as the shift from one category to another occurred. Cofer (1965) demonstrated that associative and categorical clustering are independent kinds of organization since categorical clustering occurs even when word associations have been controlled.

Tulving (1968) demonstrated that most subjects provided their own subjective organization. He gave subjects a list of 16 unrelated words with instructions to recall as many as possible and in any order they wished. The order of the words in the list was changed from presentation to presentation to prevent associations based on consecutive words. The results demonstrated that subjects provided their own organization, clustering more words together on each trial. The correlation between degree of organization and recall was .96 demonstrating that organization produces better recall. Mandler and Pearlstone (1966) demonstrated that subjects who provided their own organization rather than using categories which were provided for them required fewer trials to consistently sort a set of 52 words, each printed on a separate card. Once the organization had been learned however, there was no difference between groups on a retention test suggesting that the origin of the organization was not important.

Controversy has existed over the contribution of organization to the storage of information versus its contribution to the process of retrieval (Pollio, 1974; Tulving, 1968; Wood & Underwood, 1967). The manner in which information is stored and how it forms a part of the stored information can be expected to affect the selection of information at recall. On the other hand, organization at retrieval would activate the appropriate information, making it more accessible from memory. Pollio and Gerow (1968) proposed that cuing by category has its most positive effect on the process of retrieval since they found no significant difference between recall accuracy of those given category cueing at the time of storage and those given cueing information at the time of a retention test. It therefore appears that category cueing information is used only after storage has occurred.

Thomson and Tulving (1970) showed that presenting cues at both learning and testing is most facilitative to free recall. The importance of consistency of both encoding and retrieval cues has become known as the "encoding specificity principle" (Tulving & Thomson, 1973; Wiseman & Tulving, 1976). The principle suggests that items are stored in memory the way they are first perceived and that the particular manner of encoding determines the kinds of retrieval cues that will permit access to stored information. Also, the closer coding and retrieval cues match each other, the better the recall. In other words, the information used in retrieval must be stored with the information at the time of learning. The principle also implies that precision and distinctiveness of cues linking encoding and retrieval is important to recall (Craik, 1977; Stein, 1978).

Having examined many of the features of long- and short-term memory based on the information processing view of the duplex model, a major alternative to structural memory functioning will now be presented.

2.4 A Process Model of Memory

2.4.1 Overview

As in all sciences, the study of memory has produced data which may have several alternative explanations. A model of memory which does not adopt the view that long- and short-term retention are based on different memory structures, is the levels of processing model described by Craik and Lockhart (1972). They proposed that memory be thought of as the end product of the kinds of processes performed on the information we receive from our environment. Basically, this position views memory within the context of a system which is capable of a number of different analyses on information. These analyses are seen in terms of a hierarchy moving from the sensory analyses of the physical properties of a stimulus such as shape and size, through identification and naming of the stimulus and finally to the meaning of the stimulus.

The memory code or the method of information storage, according to Craik and Lockhart (1972), is seen as a record of what processes were carried out to analyze a stimulus. Each level of processing produces a memory code or trace moving from shallow codes produced at the earliest level to deeper codes, including semantic representations and associative relationships. This early view of the levels of processing model also proposed that codes were less easily forgotten when they were processed more deeply. Memory for a stimulus is limited by the depth of processing that circumstances permit. If material is presented rapidly and has relatively little personal meaning, the subject will restrict the amount of processing. From a structural model viewpoint, the limitation in short-retention and the rapid loss of lower level acoustic codes were used as evidence for a short-term store. The processing view proposes that limited capacity may have been a consequence of the meaningless of materials used in studies and the little time allowed to process information to a deeper more meaningful level.

A further assumption of this model is that processing requires attentional resources, therefore the amount remembered will depend on the attentional capacity devoted to analyzing the stimulus. The results of studies examined earlier which provided evidence for a short-term store, might also be interpreted as the result of limitations in processing capacity restricting the depth of encoding.

Studies on the duplex memory model examined the relative duration of short- and long-term memory, their capacities and the kinds of codes used in each. In the levels of processing framework, the duration of a memory has nothing to do with which store contains the information. Instead, it depends on what the subject does with the stimulus material, how it is analyzed, and what codes are created in the analyses (Wingfield & Byrnes, 1981, p.284). The effect of depth of processing on retention performance has been demonstrated by Hyde and Jenkins (1973) and Craik and Tulving (1975). In these studies, subjects were asked questions regarding the physical characteristics of words, the sound of a word, or the meaning of a word. This was followed by a surprise retention test of the words presented in the study. Both demonstrated that retention was significantly better after semantic processing and the Craik and Tulving research showed an additional element of time. Deeper processing required more time than shallower processing.

Rehearsal, according to the original levels of processing view, kept material in immediate awareness, at the level of an acoustic code, for rapid retrieval, but did not serve to increase the strength of the memory trace (Craik, 1970; Craik & Watkins, 1973). Craik attempted to make a distinction between maintenance rehearsal and elaborative rehearsal in the face of evidence that rehearsal did improve retention (Dark & Loftus, 1976). This distinction was later abandoned in favour of the view that memory maintaining activities can take a variety of forms (Craik, 1979). It is the extensiveness of processing at any given level that will increase the durability of a memory code. This notion of the extensiveness of processing as opposed to depth has provided the most profound modification to this theory.

2.4.2 Amendments to the Processing Model

In attempting to define and measure "depth" of processing, circularity was encountered for which Craik and Lockhart were criticized (Baddeley, 1978; Eysenck, 1978). Better retention was used to measure depth of processing and depth of processing was used to explain better retention. As the processing view developed, Craik and Tulving (1975) introduced the notion of "spread" or elaboration of encoding. While depth referred to the types of operations or analyses performed on the information, spread referred to the number of operations carried out at one level. This formulation was proposed as a result of studies showing that surface characteristics of stimuli perceived as a shallow processing, can be retained over time. For example, we remember a speaker's voice long after hearing it (Craik & Kirsner, 1974).

Spread of encoding implies that features of the context are added to the memory code, making the code unique and therefore easier to identify. Craik and Tulving (1975) demonstrated the effects of spread of processing by presenting words with different degrees of context information to subjects and examining subsequent retention. The experimental design necessitated the processing of all words at the semantic level. Results showed that the richer context allowed for elaboration of the meaning of the word and consequently, better retention. Spread of encoding can also refer to mnemonic strategies such as rehearsal and organization (Guttentag, 1985; Kail, 1984; Salthouse, 1982) and changes in performing these operations have been observed across the life-span. It appears that young children perform similarly to older adults in the use of elaborative strategies showing the poorest recall of information (Craik & Simon, 1980; Perlmutter & Mitchell, 1982). Performance improves during the elementary school years, peaks during young adulthood and declines in old age (Guttentag & Siemens, 1986). Elaboration was subsequently included as an amendment to the depth of processing model.

A second amendment to the depth of processing view was that "distinctiveness" enhanced both deep and elaborate processing (Lockhart, Craik, & Jacoby, 1976). Research on distinctiveness has been done by Stein (1978) and Kolers and Ostry (1974). Both of these studies demonstrated that performance on recognition tests was determined by how well encoding operations incorporated context to make events different from one another at the same level of encoding. Although deeper encodings still produced better results than shallow encodings, both codes were better recognized when they were more unique.

Encoding specificity is another important principle which has been added to the processing view of memory. It was first demonstrated by Tulving (1968) and proposes that the use of cues for the retrieval of information in memory are effective only when they elicit the same encoding processes which occurred at initial encoding. Initially, Craik and Lockhart (1972) emphasized the conditions of encoding in processing information but subsequent research lead to a reformulation of the theory (Fisher & Craik, 1977; Morris, Bransford, & Franks, 1977; Nelson, Walling, & McEvoy, 1979). Fisher and Craik had subjects memorize a list of words which were presented in capital letters. They presented the to-be-remembered words (list words) with a word in small case letters (context words) which either rhymed with the list word or had a similar meaning. Immediately following presentation of the words, subjects were either given identical, similar or completely different context words and asked to retrieve the list words. Results showed that the more compatible the encoding and retrieval conditions, the better the recall. But when compatibility was held constant, the deeper semantic encoding was superior to the shallow rhyming encoding. The amendment to the theory therefore, was that both the depth of the code and the compatibility between encoding and retrieval are crucial to determining memory performance.

A final amendment to the theory, proposed thus far, relates to the processes of attention and resource allocation in memory coding. Eysenck and Eysenck (1979), using a divided attention task, demonstrated that more resources are expended in semantic tasks. They measured the reaction times of individuals engaged in answering questions which required either semantic processing or shallow processing (looking for the presence of a letter in a word). Subjects who were processing information semantically did so more quickly than subjects processing at a shallow level, but required more time to perform the simple reaction time task. The results indicate that although processing time cannot be used as a measure of depth, which supports results obtained by Craik and Tulving (1975), deeper processing requires more capacity. Craik (1984) has used the idea of reduced processing resources to carry out effective encoding and retrieval operations, as an explanation for poor memory performance in aging.

Although the amendments have answered many criticisms of the theory and explained new data, some researchers fear that the theory may become too cumbersome to be useful (Kolers, 1979; Tulving, 1979). On the other hand, the process view of memory is increasingly replacing the structural model as a memory model in research (Craik & Simon, 1980; McDowall, 1984; Guttentag, & Siemens, 1986; Wingfield, 1980).

2.4.3 Summary

The present chapter has examined the theory put forth in recent years to explain the complex phenomenon of memory. Although controversy regarding the presence of discrete memory stores exists, great strides have been made in advancing the study of memory. The next chapter focuses on physiological findings which have served to unravel the mystery of human memory and the measures developed to assess this function.

Chapter III

NEUROPSYCHOLOGY OF MEMORY

3.1 Synopsis of the Chapter

The present chapter begins with an examination of the neurological substrates underlying memory functioning in the brain. Memory dysfunction associated with lesions to the medial temporal lobes and the diencephalon are discussed. This is followed by theoretical and clinical considerations of the present state of memory assessment and finally a review of the Rey-Osterrieth Complex Figure Test is presented.

3.2 Memory Localization in the Brain

3.2.1. Introduction

In recent years, neuropsychological investigations of memory have focused increasingly on the neurological substrates involved in this complex cognitive function (Olton, 1989; Russell, Hendrickson, & VanEaton, 1988; Smith, & Milner, 1989; Winocur, 1984). Although numerous brain centers have been implicated, two regions have received special attention: the medial temporal lobe and the diencephalon. Each of these regions has been associated with specific organically based disorders and specific memory based operations. Analogous animal research, where brain lesions have been produced surgically, has also complimented the research on memory impaired humans. Both of these brain regions and the functions associated with each are discussed in the following section.

3.2.2 Memory and the Medial Temporal Lobe

An association between the medial temporal lobe (MTL) and memory has been widely accepted since the work of Milner and her colleagues (Milner, Branch, & Rasmussan, 1962; Scoville, & Milner, 1957). Following autopsy of the brains of several amnesic patients who had undergone temporal lobectomy, a correlation was reported between the severity of memory loss and the extent of damage to the hippocampus, a structure within the MTL. No other affected brain structure yielded this type of relationship.

Scoville and Milner's (1957) description of the famous patient H.M. provided the most widely accepted support for the duplex hypothesis of memory postulating a two memory system including short-term and long-term memory. After the bilateral removal of parts of the temporal lobe and the hippocampus for the treatment of epilepsy, H.M. was left with normal intelligence and an ability to remember those long-term events which occurred prior to the operation, but the acquisition of new material on a permanent basis was impossible.

Although surgery for the removal of the epileptogenic focus still provides the best hope for seizure relief in severe epileptics (Delgato-Escueta & Walsh, 1983), great care is presently taken to insure that global amnesia will not result. Specific verbal and non-verbal memory deficits have been reported by Milner (1975) and L.B. Taylor (1968) in patients with complex partial seizures (Halgren, 1984) seen in epilepsy which originate in either the dominant or non-dominant temporal lobes respectively. These memory deficits are useful in lateralizing the seizure focus (Penfield & Milner, 1958). However, before surgery is performed, a thorough evaluation of the contralateral MTL is required to determine if it can support memory. One technique developed to assess the contralateral temporal lobe is the intracarotid sodium amytal test (Milner et al., 1962). Following injection of sodium amytal, one hemisphere is anesthetized for about three minutes. During this brief period, a number of simple verbal and non-verbal memory tasks are performed by the patient. If the nonanesthetized hemisphere has a damaged MTL, the patient will be temporarily amnestic. This form of assessment has provided the most dramatic evidence for the involvement of the MTL in memory (King et al., 1986).

3.2.3 Hemispheric Specialization

On the basis of reports of memory deficits in temporal lobe epilepsy and temporal lobectomy (Milner, 1975), hemispheric effects have been suggested. While semantic memory appears to be localized to the left temporal-hippocampal complex, figural memory is associated with the right hemispheric region. Unfortunately, this relationship has not always been as clear as the theory predicts. Milner (1975) describes patients with a left temporal lobe focus who show semantic memory impairment but right temporal focus patients do not always show figural memory deficits. These are only observed after right temporal lobectomies. This may suggest that the left hemisphere may partially compensate for figural memory deficits and lateralized effects are only clearly observable after surgery. In addition, memory in the contralateral hemisphere has in fact improved following temporal lobectomies suggesting pathological influences of diseased hemispheres on intact hemispheres (Cavazzuti, Winston & Baker, 1980; Novelly et al., 1984).These observations have raised questions about the simple laterality model of memory.

Early onset of abnormalities has been suggested as a possible explanation for anomalous hemispheric representations of function in the brain (Milner, 1975). Although the effects of early lesions on general intellectual functioning and language development have received attention (Smith, 1981), very little research has been done on memory problems associated with early lesions. In a recent study, Saykin, Gur, Sussman, O'Connor and Gur (1989) demonstrated that early onset of temporal lobe epilepsy is associated with greater memory impairment and lower IQs. They examined 30 right-handed, left speech dominant patients before and after temporal lobectomies. Preoperatively, left temporal patients showed worse semantic memory than figural memory while the right temporal patients showed no consistent pattern of impairment. Following surgery, early onset left temporal patients showed worsening of both semantic and figural memory while late onset left temporal lobe patients only showed a worsening of semantic memory. Right temporal lobectomy patients improved in both semantic and figural memory regardless of age of onset. Saykin et al. (1989) suggest that their findings support the hypothesis that the left hemisphere is better able to cope with the "crowding effect" (Milner, 1974) of both semantic and figural memory into one hemisphere. The more general findings of this study lend support to the role of the temporal-hippocampal complex in memory and the differential effects of early brain damage on memory functioning.

Another recent study conducted by Dennis, Farrell, Hoffman, Hendrick, Becker and Murphy (1988) examined the memory functioning of patients after temporal lobectomies for seizure disorders. Their results demonstrate that the risk of memory impairment is increased by seizures beginning in infancy or childhood but not by early febrile seizures in the first year of life. Their results also supported the distinction between episodic and semantic memory; a distinction currently used in memory theory. Individuals with left lobectomies were less successful in identifying an item in the specific context in which it had been presented (episodic memory) than those who had undergone right-sided surgery. The identification of semantic attributes of items and their serial positions was not dependent on laterality but rather on the degree of tissue loss and the presence of childhood seizures. They conclude that memory loss with temporal lobectomies is significant even in childhood and far more complex than supposed by previous researchers.

3.2.4 Focal Lesions of the Temporal Lobes

Effects of anterior temporal lobectomies have been studied by Ivnik, Sharbrough, and Laws (1987). They assessed 63 patients, using the Wechsler Memory Scale, who had undergone surgery and found that anterior left temporal lobe removal impaired verbal memory but performance on tests of visual recall improved. Right temporal lobectomies did not substantially alter recall in either content area. When a more complex test of verbal learning and memory (Auditory Verbal Learning Test-AVLT) was used, impairments in immediate verbal recall, learning over trials, short-term and delayed free recall, recognition memory and forgetting were observed in patients with left lobectomies. Right lobectomy patients showed enhanced performance in these areas. These findings support Novelly's (Novelly et al., 1984) suggestion that lobectomies affect memory and learning differentially, depending on which hemisphere is affected. Unfortunately, to date there are no visual-spatial assessment instruments which generate findings comparable to those obtained from the AVLT (Ivnik et. al., 1987).

Studies of cerebral infarction affecting the medial temporal lobe and hippocampus have also demonstrated memory impairments. Woods, Schoene, and Kneisley (1982) reported that severe memory dysfunction requires bilateral lesions of the memory related structures of the temporal lobes. Von Cramon, Hebel, and Schuri (1988) demonstrated that severe verbal memory and learning tasks can occur after left-sided infarcts involving the posterior temporal lobe. Patients with right-sided infarcts in the posterior medial temporal lobe did not differ from normals on verbal memory and learning tests, although the tests used to measure non-verbal memory functioning were limited by the visual field defects of these patients.

Recall of spatial location in patients with left or right temporal lobe lesions was examined by Smith and Milner (1989). Two experiments measured recall immediately after presentation of an array of objects or after an intervening verbal task, a spatial task or an unfilled interval. Deficits were found only in patients with right temporal lobe lesions that included extensive removal of the hippocampal region, and only when recall was tested after delay. The intervening task had no effect on the deficit. This study demonstrates that despite a normal ability to encode location, patients with large right temporal-hippocampal lesions demonstrate an abnormally rapid forgetting of such information. The importance of measuring delayed recall in memory assessments is underlined by this research.

Mishkin and Appenzeller (1987) demonstrated that the removal of the inferior temporal lobe in monkeys resulted in a failure to perceive or identify familiar objects but did not produce a global amnesia as seen in Scoville and Milner's (1957) patient, H.M.. The production of global amnesia in monkeys required the removal of both the hippocampus and the amygdala; two structures which lie in the anterior, medial region of the temporal lobe. The task used to measure visual memory in monkeys is called a delayed nonmatching-to-sample test where the animal is presented with a distinctive object under which it finds a reward of food. The animal is subsequently confronted with two objects, one is the object seen earlier while the other is an unfamiliar object. The food is concealed under the new object and the animal is rewarded for recognizing the novel object. Memory can be taxed further by increasing the time between the initial display and the choice or by increasing the number of objects to remember. Healthy monkeys learn this task very quickly.. Removing either structure alone, has only a small effect on the animal's recognition ability. Mishkin et al. (1987) presumed from this information that one structure can substitute for the other. Removing one of the structures from both hemispheres and the other from only one hemisphere yields severe impairment but not total loss of recognition memory. Bilateral removal of both the amygdala and hippocampus in monkeys finally results in global amnesia.

Miskin's findings were replicated by L. Squire and his colleagues (Salmon, Zola-Morgan & Squire, 1987; Zola-Morgan & Squire, 1985) who confirmed the animal model of amnesia involving bilateral lesions of the medial temporal lobe. The tasks used in assessing memory functioning in animals have been analogous to those used in assessing memory in human amnesic patients, but recently Squire, Zola-Morgan, and Chen (1988) questioned the validity of generalizing the results from animals to humans based on these tasks. They wondered whether the tasks failed by monkeys with surgical impairments would also be failed by amnesic patients or would they be so easy that only the most severe amnesics would fail them. They compared the results of human amnesic patients on five tasks which figured prominently in the development of animal models of amnesia. The amnesic patients were impaired on four of the five tasks corresponding with previous findings for monkeys but were also impaired on the fifth task which is typically not impaired in monkeys with medial temporal lesions. These results indicate that four of the commonly used tasks in measuring memory impairments in monkeys are also sensitive to the memory functions that are affected in human amnesia and are therefore valid measures of memory impairments in humans.

3.2.5 Memory and the Diencephalon

In the last fifteen years, two distinct forms of human amnesia have been described (Huppert & Piercy, 1978; Mattis, Kovner, & Goldmeier, 1978; Mishkin & Appenzeller, 1987; Squire, 1981; Squire & Zola-Morgan, 1983): bitemporal amnesia described above and diencephalic amnesia. The diencephalon is a region of the brain which includes the hypothalamus, thalamus and epithalamus (Kolb & Whishaw, 1985). Diencephalic amnesia is typified by Korsakoff amnesia, a syndrome resulting from the degeneration of the thalamus produced by chronic alcoholism and by cases of trauma or infarction (Squire & Moore, 1979).

Controversy surrounds the delineation of the exact regions of the diencephalon involved in memory functioning, but the most frequently suggested region is the dorsomedial nucleus of the thalamus (Ignelzi & Squire, 1976; McEntee, Biber, Perl, & Benson, 1976; Mills & Swanson, 1978; Squire, 1981; Squire & Moore, 1979). Many have also emphasized the role of the mamillary bodies or mamillothalamic tract (Mair, Warrington, & Weiskrantz, 1979; Swanson & Schmidley, 1985). It has also been proposed that unilateral lesions to these structures cause some amnesia but bilateral damage to both structures is necessary for profound amnesic deficits (Aggleton & Mishkin, 1983; Speedie & Heilman, 1982; Squire, 1982).

3.2.6 Laterality and the Diencephalon

Studies involving the diencephalon have led to the proposal that hemispheric specialization extends to the thalamus (Squire & Moore, 1979; Teuber, Milner, & Vaughan, 1968). In general, left unilateral lesions lead to deficits in verbal memory, while right lesions lead to nonverbal deficits (Cappa & Vignolo, 1979; Speedie & Heilman, 1983; Squire & Moore, 1979). Stuss, Guberman, Nelson and LaRochelle (1988) indicate that left-right asymmetries exist at the level of the thalamus but are apparent with only relatively simple tests. When complexity increases, deficits become more general. Certain studies have suggested that unilateral left thalamic damage has caused verbal memory deficits and disorientation but that right-sided lesions showed little or no deficits (Choi, Sudarsky, Schacter, Biber, & Burke, 1983; Graff-Radford, Damasio, Yamada, Eslinger, & Damasio, 1985). Others have reported that left-sided thalamic lesions appear to have serious consequences, affecting both verbal and nonverbal memory and/or causing dementia while unilateral right damage causes only a mild nonverbal deficit (Graff-Radford, Eslinger, Damasio, & Yamada, 1984; Squire, 1982).

3.2.7 Specific Memory Deficits and the Diencephalon

The predominance of anterograde over retrograde amnesia in diencephalic amnesia has been interpreted as suggesting that this form of amnesia is mainly a deficit in learning. These amnesics appear to fail in the initial stages of information processing rather than in retrieval of information (Winocur, Oxbury, Roberts, Agnetti, & Davis, 1984). Winocur et al. (1984) propose that bilateral lesions to the thalamus result in consistent impairment in recalling material, both verbal and non-verbal, over delays as brief as a few seconds. Impairment is especially observable on tests of free recall and partial cueing procedures but recognition memory is also impaired. In contrast, medial temporal lobe amnesia appears to produce deficits in the consolidation and storage of information as demonstrated by an abnormally fast forgetting rate once learning has occurred (Huppert & Piercy, 1978; Squire, 1981).

Stuss, Guberman, Nelson, and Larochelle (1988) question the separate roles assigned to the bitemporal and diencephalic regions. The suggestion that faulty information storage is associated with temporal lobe amnesia while the diencephalic zones are involved in encoding operations was not supported by their results. Their patient, R.C., showed moderately severe retrograde amnesia in addition to anterograde amnesia with lesions limited to the diencephalon. R.C. had damage to both the dorsomedial nucleus and the mamillothalamic tract. These researchers conclude that both of these structures contribute to memory and the severity of the disorder depends upon the amount of damage, with maximum impairment if both structures are involved.

Mishkin et al., (1987) suggests that the diencephalon, specifically the thalamus and hypothalamus, and the hippocampus and amydala participate in a circuit rather than making totally independent contributions to memory. This was demonstrated by destroying, first in combination then separately, both regions of the diencephalon to which the hippocampus and amydala send fibers. Combined damage to the diencephalic structures produced severely impaired recognition memory while damage to either structure alone had only a slight effect. The circuit hypothesis was further supported when cutting the connections between the amygdala and hippocampus and the diencephalon resulted in severe memory impairment.

3.3 Problems of Memory Localization

From the studies cited above, it appears that amnesia occurs in many forms. Although amnesia has been linked to damage in the medial temporal and diencephalic brain regions, it is difficult to determine whether or not damage outside these regions may also contribute to the observed deficits. In addition, hypotheses concerning the specific contribution of different parts of the system (e.g., medial temporal and diencephalic regions) to memory functioning appear to be speculative at the present time. Squire (1986) suggests that before different forms of amnesia can be dissociated by describing functions such as forgetting rates, matching of amnesic patients with respect to initial learning ability is required. To do so will require further studies of experimental animals with identifiable surgical lesions. Meanwhile, more detailed descriptions of known disorders are required. For example, Squire has studied Korsakoff patients, an example of diencephalic amnesia, in detail and compared them to other amnesic patients. Results show that Korsakoff patients have difficulty making temporal order judgements, fail to release from proactive interference (Squire, 1982), and they cannot accurately predict their own memory performance (Shimamura & Squire, 1986). These deficits were not observed in other amnesic patients whose learning abilities were as severely impaired as the Korsakoff patients and other patients with diencephalic amnesia did not always have these deficits. These findings suggest that amnesia as seen in Kosakoff patients may involve other structures such as the frontal lobes and underlines the importance of more accurate descriptions of memory functioning within disorders. To accomplish this, greater specificity of assessment instruments is required.

3.4 Memory Assessment

3.4.1 Introduction

Given the importance of memory evaluation in contemporary neuropsychology, the psychologist must first ensure that the tests employed genuinely assess the cognitive operations of interest in order to avoid making erroneous conclusions. Regrettably, very little research has been done on modifying and validating newer measures of memory which incorporate recent research findings (Loring & Papanicolaou; 1987). Memory functioning continues to be equated, in large measure, to the scores obtained from the Wechsler Memory Scale (WMS) in spite of the severe criticism of this instrument (Erickson & Scott, 1977; Prigatano, 1978). The present section on memory assessment is not intended as a survey of the various memory tests in common use, since excellent reviews exist in the literature (Erickson & Scott,1977, Prigatano; 1978). In addition, no attempt is made to describe the specific techniques involved in memory assessment since these are readily found in excellent reference manuals (e.g.: Lezak, 1983). The goal of this section is to examine representative approaches to memory assessment currently in use and their underlying theoretical assumptions. Since the present research is examining nonverbal memory, greater emphasis is placed on this form of memory. Also, the major theoretical and clinical requirements of memory assessment outlined in the literature are discussed.

3.4.2 Theoretical and Clinical Considerations

Many forms of memory testing (free recall, cued recall, recognition) share the property that success depends upon the subject's knowledge of past events. Traditionally, measures of memory have provided instructions which make explicit reference to an episode in the subject's personal history. These tasks have been referred to as autobiographical (Jacoby & Dallas, 1981), direct (Johnson & Hasher, 1987), episodic (Tulving, 1972), explicit (Graf & Schacter, 1985; Schacter, 1987), or intentional (Jacoby, 1984). Recently, other tasks have emerged which involve no direct reference to an event in a subject's history but are influenced by such events. These have been called implicit (Graf & Schacter, 1985; Schacter, 1987), indirect (Johnson & Hasher, 1987), or incidental (Jacoby, 1984). Impressive dissociations between traditional memory tasks and the more recently developed indirect measures have been observed (Richardson-Klavehn & Bjork, 1988) in amnesic populations, revealing different aspects of memory functioning. For example, Squire and Cohen (1984) have shown that behaviourial changes caused by an event can be observed in subjects who are unable to remember that the event occurred. Because of these findings, it has become necessary to clearly describe the tasks used and the informational demands placed on the subjects when assessing memory.

Appropriate assessment of memory functioning must take into account the heterogeneity and complexity of memory breakdown in humans. As reviewed earlier, the most explored causes of memory dysfunction are related to lesions in the temporal lobes and the diencephalon. Other brain lesions which have also been associated with memory breakdown include cortical lesions resulting in short-term memory problems (Warrington & Rabin, 1971), lesions in the posterior association cortex (Warrington, 1975) disturbing semantic memories and impairing the acquisition of new knowledge, and frontal lobe lesions which disturb the ability to plan encoding and retrieval strategies (Luria, 1973). These findings suggest that it is no longer useful to speak of memory as a single cognitive process which is either dysfunctional or normal. The development of far more precise measures of memory functioning with greater specificity is required.

Mayes (1986) suggests that in addition to lesions of the brain, the ability to encode material distinctively so as to associate it with material already present in memory may be affected by motivation, state of consciousness and intelligence. This indicates that a complete memory assessment should include a test of overall intelligence such as the Wechsler Adult Intelligence Scale to obtain a more exact view of the specific operations which are most affected.

3.4.3 Measures of Memory

Despite criticisms, the Wechsler Memory Scale (WMS) remains the most widely used clinical test of memory (Erickson & Scott, 1977; Lubin, Larsen, & Matarazzo, 1984). Many of the criticisms directed at the WMS apply to other memory tests in use, therefore this instrument and its variants are examined at this time.

The lack of adequate normative data (Lubin et al., 1984) has been one of the most frequently mentioned criticisms of the WMS because the original report provided subtest norms on only two age groups with a total sample size of 96 (Wechsler, 1945). Sex has been shown to have a significant effect on spatial abilities (Harris, 1978; Orsini, Chiacchio, Cinque, Cocchiaro, Schiappa, & Grossi, 1986) and educational background has a major influence in determining performance on the WMS (Gilleard & Gilleard, 1989) but these issues are not considered in the norms. Other criticisms refer to the assumption that memory is a unitary concept which can be described by a single memory quotient and that the test includes constructs which are not genuine measures of memory such as the Orientation and Mental Control subtests (Erickson & Scott, 1977; Prigatano, 1977, 1978). One of the most obvious shortcomings of the WMS is that it fails to measure delayed recall of either verbal or visuospatial memory. Roth and Crosson (1985) demonstrated that delayed recall measures were the most sensitive in detecting memory deficits and should be included in most neuropsychological assessments.

In an attempt to remedy some of the limitations of the WMS, Russell (1975) examined the factor structure of the test and selected the Logical Memory and Visual Reproduction subtests as the most sensitive to detect brain damage. In addition, these tests differentiated verbal from figural memory. The remainder of the subtests were discarded since they failed to differentiate brain-damaged from non-brain-damaged or did not measure memory per se. A delayed recall condition was also included for both subtests. Recently, Russell (1988) has renormed his version of the WMS since several studies appeared to show that the original norms were to some extent incorrect (Crosson, Hughes, Roth, & Monkowski, 1984; Haaland, Linn, Hunt, & Goodwin, 1983).

The Visual Reproduction subtest of the WMS is a widely used measure of nonverbal memory (Crosson, Hughes, Roth, & Monkowski, 1984; Loring & Papanicolaou, 1987; Russel, 1975, 1981, 1982). Unfortunately, factor-analytic studies of this subtest have revealed that it may be assessing a visual-perceptual-motor ability with memory contributing only a minor role (Ivinskis, Allen, & Shaw, 1971; Larrabee, Kane, & Schuck, 1983; Larrabee, Kane, Schuck, & Francis, 1985). Silverstein (1962, 1963) found similar results with the Benton Visual Retention Test. However when delayed visual reproduction is measured, the results load on a memory factor rather than on perceptual motor functioning and could be used to discriminate for right unilateral temporal lobe activity (Delaney, Rosen, Mattson, & Novelly, 1980). Loring and Papanicolaou (1987) conclude that the only genuine measure of figural memory performance appears to be the delayed component, but since constructional abilities may be impaired without a corresponding deficit in visual spatial memory, recognition assessment should also be routinely performed.

In the section on visual memory, Lezak (1983) reviews the most widely used measures of this cognitive process. These include the visual reproduction subtests of the Wechsler Memory Scale (Wechsler, 1945), the Complex Figure Test (Rey, 1941; Osterrieth, 1944), the Benton Visual Retention Test (Benton, 1974) and the Memory for Designs Test (Graham & Kendall, 1960). Since the focus of the present study is on the Complex Figure Test, this measure is thoroughly reviewed in the following section.

3.5. The Complex Figure Test

3.5.1 Origin of Test

The original figure used in this test was devised by Rey (1941) as a measure of perceptual organization and visual memory. Later, Osterrieth (1944) standardized Rey's procedure by investigating the performance of 230 normal children between the ages of 4 and 15 and 60 adults ranging from 16 to 60 years. In addition, Osterrieth examined children with learning and adjustment problems, behaviorally disturbed adults, 43 brain injured patients and some patients with endogenous brain disease. The results were analyzed in terms of how subjects drew the structural elements of the Rey-Osterrieth figure with considerably less emphasis on the mnesic aspects of the results. A second form of the test for use in retesting was developed by Taylor (Milner, 1975; Taylor, 1969, 1979). The results of a study conducted by Powell (1979) indicate that the Complex Figure Test relates more ~~to~~ the spatial IQ of the WAIS than to the verbal IQ.

3.5.2. Interpretation of the Complex Figure Test

In addition to the copy phase of the test, both an immediate and a delayed recall trial are required. This permits examiners to sort out different aspects of constructional and memory deficits (Wood, Ebert, & Kinsbourne, 1982). As discussed earlier, the delayed trial is of vital importance in assessing non-verbal memory but the length of the delay can vary between 30 minutes and one hour without affecting the final results (Wood et al., 1982). In addition, the unpublished dissertation of Viola Ebert (1979, cited in Wood et al., 1982) provided evidence that subjects performances rarely show more than a few point differences between the immediate and the delayed recall trials.

The results of the Wood et al. (1982) study divided subjects into two groups. Those patients with left-sided lesions preserved the overall shape of the figure but had a tendency to omit details, demonstrating difficulties in organizing complex data. Osterreith (1944) stated that the performance of these patients will often improve on the immediate recall trial. Patients with right hemispheric lesions in the Wood et al. (1982) study tended to lose the general organization of the figure and distorted and displaced details. They also have greater difficulty with recall (Milner, 1975; Taylor, 1969). When assessed with the Complex Figure Test, subjects are not informed during the copy phase that recall of the figure will follow. Hasher and Zacks (1979) made a distinction between effortful and automatic attentional operations to distinguish between processes that require mental effort or concentration and those that place only minimal demands on attentional capacity.

They reported that spatial and temporal aspects of stimuli as well as frequency of occurrence of information are memory features which are encoded automatically and do not decline with age. In fact, paying attention to information that is otherwise encoded automatically does not improve on the encoding of that information. Attig and Hasher (1980) and McCormack (1981, 1982) have found similar results. Mandler, Seegmiller and Day (1977) obtained very small differences in recall of spatial information where information was either explicitly encoded or incidental. Moore, Richards, and Hood (1984) did find differences on the Tactual Performance Test when encoding was either explicit or incidental but this may be related to tactual nature of the task. Riege and Inman (1981) demonstrated that the right hemisphere undergoes an age decrement in the ability to process tactual memory. These findings seem to support the procedure of not informing subjects during the copy phase of the Complex Figure Test of the upcoming recall phase.

In spite of the positive view of the Complex Figure Test found in the literature regarding its clinical utility, very little research has actually been done on the test itself. It has been used as part of a battery in a number of studies (e.g.: Becker, Boller, & Saxton, 1987; Lendrum & Lincoln, 1985; Levine, Warach, Benowitz, & Calvanio, 1986) as a measure of non-verbal memory functioning but its validity was not questioned in these studies.

3.5.3 Differential Diagnosis and the Complex Figure Test

Studies which examined the validity of the Complex Figure Test most often involve the differentiation of clinical populations. Toullat and Lefevre (1981) found that the test was useful in differentiating patients with brain lesions from those suffering from neurotic disorders. Perseverations, omissions, substitutions occurred in the reproductions of brain damaged patients while these were not observed from neurotic patients. The total number of errors was also an indicator of brain damage.

Klicpera (1983) examined normal readers, poor readers and dyslexic subjects using the Complex Figure Test and found that subject's ability to organize their drawings in order to ensure better encoding differentiated the groups. No clear differences were found between poor readers and normal readers but the dyslexic subjects were clearly poorer in reproducing the structure of the complex figure and less systematic in their approach to the task.

King (1981) tested the visual memory of patients with brain dysfunction. Results showed that age and intelligence were inversely related to task performance and brain-damaged groups performed more poorly than normals. In contrast to findings of other studies of patients with focal brain damage (e.g.: Powell, 1979), King (1981) did not observe differences between subjects with right hemisphere lesions and those with left hemisphere lesions. The absence of differences found between the two groups may be related to the slow organization of complex data and impaired planning ability observed in patients with left-sided lesions (Wood et al., 1982) resulting in poor encoding.

In a study where subjects with specific brain lesions were assessed using the Complex Figure Test, Ducarne and Pillon (1974) found that abnormalities in certain brain regions were associated with specific types of errors. All patients had visuo-constructive problems, but those whose lesions were in the left parietal area produced a primitive structure with oversimplified elements. Patients with right parietal lesions were characterized by unilateral omissions of the left part of the figure and displacement of some details on the left side toward the right. Those with occipital lesions produced detailed analytic structures and had difficulties in closing the body of the figure and its elements.

In a study comparing patients with Alzheimer's disease and those with a closed head injury (Bigler, Rosa, Schultz, Hall, & Harris, 1989), performance on the Complex Figure Test was impaired in both groups. The degree of impairment differentiated the groups with Alzheimer patients showing substantially greater copying and recall deficits.

3.5.4 Developmental Changes and the Complex Figure Test

Waber and Holmes (1985), using the results obtained from 454 normal children ranging in age from 5 to 14 years, examined the copy productions of children to determine developmental changes. They examined production style, accuracy and organization and found that by 9 years of age, subjects could rapidly produce all the parts of the design. Changes in performance occurring after that age primarily reflected the capacity to plan and organize the material in an effective fashion. As a follow-up, Waber and Holmes (1986) published a system for objectively evaluating organization, production style and accuracy making it a useful instrument in the neuropsychological assessment of children.

3.5.5 Studies Involving Normal Subjects

Bennett-Levy (1984) administered the Complex Figure Test to 107 volunteers between the ages of 17 and 49 years. The purpose of the study was to determine a quantitative measure of copying strategy and to investigate its relationship to the copy score and recall performance. The results showed that both immediate copy and delayed recall were related to age, but most significantly in the strategy adopted at the initial copy. Based on these results, recall deficits due to a failure of organization at input and those due to forgetting can be differentiated.

A second study conducted by Chilean researchers (Servat & de Urarte Izeta, 1984), found significant correlations between IQ level and performance on the Complex Figure Test. Their subjects were hospitalized maternity patients with IQs ranging from 50 to 110.

3.6 Summary

Experts in the field of neuropsychological testing (Lezak, 1983) have stated that the Complex Figure Test, widely used in the assessment of non-verbal memory, is a useful clinical instrument in differentiating organic and functional disorders. In spite of this, some difficulties still exist in the interpretation of the results obtained on the CFT since numerous cognitive processes are required to succeed on the task. This may explain the limited number of studies conducted on the validity and reliability of the Complex Figure Test. Separating out the factors which are not measuring non-verbal memory may improve the clinical utility of the instrument. The next chapter describes the method used in attempting to accomplish this task.

Chapter IV

METHOD

4.1 Introduction

This chapter delineates the method of the dissertation. It begins with a description of the subjects and materials used in the investigation, followed by an account of the procedures utilized to collect the data. Finally, a description of the statistical analyses performed on these data are provided.

4.2 Subjects

The subjects who participated in the present study were all patients at Alberta Hospital, a psychiatric hospital in Edmonton, Alberta, Canada. They consisted of consecutive referrals to the department of Neuropsychology over a two year period. Only those subjects who were able to complete all tests were included.

Two groups were formed from consecutive referrals, beginning in April of 1987. At that time, the Rey-Osterrieth Complex Figure Test (CFT) was introduced as a regular test in the standard neuropsychological battery administered at the hospital. The number of subjects who completed the battery during a one year period and were between the ages of 15 and 50 was 50. This particular age group was selected since only a small percentage of subjects fell outside this age range.

In June of 1988, the Sequential Complex Figure Test (SCFT) replaced the CFT in the battery of neuropsychological tests and data were once again collected over a one year period. The number of subjects who completed all tests and whose ages fell within the specified range was 68.

The sample of psychiatric patients forming both groups suffered from a variety of psychiatric disorders, but schizophrenia and depression were most common. Other diagnosis taken from patient profiles included chronic alcoholism, epilepsy, and post-traumatic disorder resulting from closed head injuries. The majority of patients had been unmedicated for at least one month prior to testing. Only two chronic schizophrenics who were stabilized on anti-psychotic drugs were tested while on medication.

The ratio of males to females was 2:1 in the first group and the average age was 31 years. The second group had an average age of 27 and the male to female ratio was 5:2. Gender was not used as a criterion for selection but the gender composition of each sample was approximately equal to that of the psychiatric population overall. Examination of the sample groups on gender, IQ, and diagnosis revealed relatively homogeneous group compositions.

4.3 Materials

A number of neuropsychological tests was used in the present study. One purpose of the study was to compare the Rey-Osterieth Complex Figure Test (CFT) and the Sequential Complex Figure Test (SCFT), therefore the first group was tested on the CFT while second group was tested on the SCFT. A second purpose of the study was to determine if each of the experimental tests measured the same cognitive functions, therefore other nonverbal memory tests were administered along with tests which putatively assessed frontal lobe functions such as organization and planning. The results of the later tests were correlated with those obtained from the CFT and the SCFT to uncover the amount of shared variance, if any. Each of these instruments will be described in the following section.

4.3.1 Rey-Osterrieth Complex Figure Test

As reviewed in Chapter III, the Complex Figure Test (CFT) (Rey, 1941; Osterrieth, 1944) is a measure of both perceptual organization and visual memory. The test materials in the present study consisted of Rey's figure and blank letter-size paper placed horizontally before the subject. While the subject copied the figure, the examiner recorded the sequence of the segments drawn. This provided information regarding the strategies employed to reproduce the figure. Although there was no time limit, time to completion was recorded. The average time required for completion was 3 minutes. Very quick reproductions suggested carelessness while slow reproductions indicated a lack of concentration. The figure was removed immediately upon completion of the copy phase and the subject was asked to draw the figure from memory. Following the immediate recall condition, a delayed condition occurring 45 minutes later is administered. During the 45 minute delay, other tests were administered. In this investigation, each drawing was scored according to the method outlined by Denman (1984) with a maximum score of 72 for each phase. Three scores were recorded per subject: a copy score, an immediate recall score, and a delayed recall score.

4.3.2 The Sequential Complex Figure Test

The idea for this adaptation of the Rey-Osterrieth Complex Figure Test came from a paper by L'Hermitte, Derouesne, and Signoret (1972). The test was normed by Read (1987) on a group of 734 volunteers between the ages of 50-79 years. Jones-Gotman (1986) also used a similar method in her studies carried out with temporal-lobe epileptics. No other studies using this adaptation have been found by this investigator. The name Sequential Complex Figure Test (SCFT) was selected by the present investigator to maintain continuity with previous research on this test.

In the present research, the SCFT consisted of Rey's original figure divided into eighteen components and presented one at a time on 5x8 inch cards in a booklet format. The first component was printed in black in the center of card one. The second card showed the same figure printed in dashed lines with a new component drawn in a solid black line. Each subsequent page consisted of the components previously presented as dashed lines with a new component shown in solid lines (see Appendix A). The subject was requested to draw the first component and add each component printed in solid black lines on subsequent pages to their existing drawing. This process continued until the figure was complete. The average time required to draw the entire figure was three minutes. This procedure was followed by an immediate recall condition and a delayed recall condition, 45 minutes after the initial presentation.

In the present investigation, scores for the copy, immediate recall, and delayed recall drawings were obtained using the method outlined by Denman (1984). This detailed method of scoring, used with both versions of the test, permitted direct comparison of the results for all three conditions.

4.3.3 The Wechsler Adult Intelligence Scale-Revised

The WAIS-R (Wechsler, 1981) is an individually administered, composite test used to measure intellectual functioning. It consists of eleven subtests measuring a variety of abilities which are not easily defined. In spite of this, research has demonstrated that the WAIS-R has considerable clinical utility and is effective an a diagnostic instrument (Heaton, Baade, & Johnson, 1978).

In most neuropsychological investigations, the WAIS-R constitutes a substantial portion of the examination (Lezak, 1983). In addition to providing an estimate of global intellectual functioning, the scales provide separate scores for verbal and for performance subtests which have proved extremely useful as a rough measure of left and right hemispheric functioning (Kolb & Whishaw, 1985; Matarazzo & Herman, 1984). Because of this property, the WAIS-R was used in the present investigation for comparative purposes. The results of both the CFT and the SCFT were correlated with WAIS-R results in order to determine if there was overlap between the measures.

4.3.4 Tactual Performance Test (TPT)

The TPT is a modified version of the Seguin-Goddard Board from the Arthur (1947) battery developed by Halstead (1947) as a measure of tactile form discrimination. Subjects in the present study were blindfolded and required to place 10 wooden blocks in a formboard with the preferred hand, nonpreferred hand, and both hands respectively. The time for each of these trials was recorded. Subsequently, subjects were asked to draw from memory, as many shapes as they could remember, in their correct spatial location if possible.

The complexity of this test makes it a good measure of global brain functioning. The functions measured by the test include psychomotor ability, tactile memory and discrimination, incidental learning, and organizational abilities.

Information derived from the comparative performance of both hands provides evidence of lateralization effects (Reitan & Wolfson, 1985). Motoric and organizational strategies versus spatial and tactile deficits may also localize dysfunction along an anterioposterior gradient (Golden, Osmon, Moses, & Berg; 1981).

Because of its nonverbal memory component, the TPT was included in this investigation in order to determine if a relation between the memory and localization scores and the results of either or both the CFT and the SCFT existed. The results of the TPT were also correlated with the results of the other tests used in this study. In the present investigation, the TPT was scored according to guidelines developed by Yeudall, Reddon, Gill, and Stefanyk (1987).

4.3.5 The Benton Visual Retention Test (BVRT)

The BVRT (Benton, 1974) is a widely used test which measures visuomotor functioning, visuospatial perception, visual and verbal conceptualization, and immediate memory span (Lezak, 1983). It has three equivalent forms and provides norms which account for both age and estimated intellectual ability. The BVRT is a very stable and reliable test (Lezak, 1983) providing similar results even after a 12 month delay.

Recent research on the factor structure of the BVRT (Moses, 1986), showed that the constructional or copying component of the test outweighed the memory component. This may be related to the lack of a delayed recall phase of the test in its standard administration. The test has proven to be very successful at distinguishing patients with cerebral brain damage from those with psychiatric disorders and at measuring cognitive declines associated with normal aging (Heaton, Baade, & Johnson, 1978; Marsh & Hirsch, 1982).

Administration A was used in this investigation which allowed a ten second exposure to each of ten cards followed by the immediate recall of the figure. The number of correct designs and the number of errors were tabulated for each design. Since six possible types of errors were scored, more than one error per card was possible. It was used in the present study to determine if the CFT and the SCFT were measuring similar abilities by correlating the results of each with those obtained from the BVRT.

4.3.6 The Halstead Category Test (HCT)

The HCT is a complex, abstract concept formation test (Pendleton & Heaton, 1982) which requires the ability to recognize recurring similarities and differences in testing material and form a hypothesis which will account for these relationships. This hypothesis is then tested by the subject through positive or negative feedback provided after each response by the examiner.

The HCT is composed of 208 items presented in seven subtests which are each organized around a central principle, except the last subtest which is a review of the six previous subtests. Visuospatial skills plus learning, attention, concentration and memory are abilities required for good performance on the test. Reitan and Wolfson (1985) and Boyle (1988) describe the HCT as a generalized measure of cerebral integrity, while Golden et al. (1981) view it as a measure of prefrontal lobe functioning. Recently, Corrigan, Agresti, and Hinkeldey (1987) reported significant correlations between HCT total errors and PIQ from the WAIS-R and between total errors and age. These results were consistent across two distinct populations of brain damaged subjects but, unlike the PIQ, the HCT was not susceptible to lateralized effects.

In the present study, the test was administered according to standard procedures and results were correlated with those obtained from the CFT and the SCFT.

4.3.7 The Wisconsin Card Sorting Test (WCST)

The WCST (Berg, 1948; Grant & Berg, undated) is a widely used measure of concept formation, abstract thinking and flexibility in shifting set (Lezak, 1983). Good performance on the WCST has been associated with frontal lobe integrity (Drewe, 1974; Milner, 1963). Robinson, Heaton, Lehman, and Stilson (1980) found that both frontal lobe dysfunction and diffuse impairment resulted in poor performance on the test. Taylor (1979) reported that perseverative errors were associated with frontal lobe damage but more patients with left-sided frontal lobectomies demonstrated permanent impairments than those with right-sided impairments.

The subjects in the present study were asked to sort a pack of cards by placing them under one of four stimulus cards. The object of the test was to sort according to color, form, or number depending on the examiner's response to the placement of the cards. The examiner shifted principles after ten correct card placements without notifying the subject. Relying on feedback from the examiner, the subject determined which principle was required. The test continued until six successful runs of ten cards each or all 128 cards were placed. Results were scored according to guidelines published by Yeudall, Fromm, Reddon, and Stefanyk (1986).

Both the HCT and the Wisconsin Card Sorting Test (WCST) were included in this investigation because they are putative measures of frontal lobe functioning. Since it is postulated that intact frontal lobe functioning is required to reproduce the Rey-Osterrieth figure (Pillon, 1981), a stronger relationship between the CFT and the frontal lobe measures was expected than between the SCFT and these measures.

4.3.8 L.J. Tactile Recognition Test

This test was designed in 1972 by Yeudall and Kisilevich as a non-verbal form of the Tactile Form Recognition Test used in the Halstead-Reitan battery. The L.J. Tactile Recognition Test (Yeudall, 1983) is intended to be more sensitive than the Tactile Form Recognition Test to right parietal functions. Few errors are made by normal subjects on this test. Interhand differences in error and time scores suggest a hemispheric effect for the nonpreferred and both hands scores. No age differences are typically seen on error scores, but for time, significant effects of age are seen on the score for both hands. Normative data are available in Yeudall et al. (1986)

Subjects in this study were given one asymmetrical shape at a time to feel and were required to match the shape to one of four shapes. The time taken to point to the appropriate shape and the number of errors for preferred, nonpreferred, and both hands was recorded.

The L.J. Tactile Recognition test was selected for comparative purposes because of its nonverbal characteristics. Since the shapes are asymmetrical, they cannot easily be verbally coded, increasing the likelihood of right hemispheric functioning during the performance of the test. Because memory is not measured by the L.J. Tactile test, strong positive correlations between the test and the CFT or the SCFT would suggest that the latter tests are not primarily assessing memory.

4.4 Procedure

All subjects involved in the present investigation were assessed by three trained technicians with several years of neuropsychlogical testing experience. Subjects were motivated to achieve their best performance and testing conditions were excellent. Because of the length of the battery, technicians monitored subjects for any signs of fatigue and provided breaks when necessary. Testing was discontinued if, for any reason, the subject was unable to perform tasks adequately.

All tests were administered according to test manuals and scored using standard procedures. If a subject's profile contained incomplete tests, it was eliminated from the study. Tests were administered in the same order for all subjects.

Subject profiles were carefully examined by this investigator to insure that all procedures were followed correctly. Identical SCFT test booklets, prepared by this writer, were provided for the technicians as well as written instructions obtained from Read (1987). To insure accuracy of results, subject profiles were exchanged between examiners and rescored. Any discrepancies were discussed with the writer and corrected.

4.5 Hypotheses

The hypotheses to be tested in the present study were that altering the method of data presentation on the CFT would not have an effect on the results and that both the CFT and the SCFT were measuring the same functions. Gender differences were not expected on either form of the test. Based on these, the following statistical assumptions were made.

4.5.1 Encoding differences

It was predicted that subjects who were tested on the SCFT would have significantly higher copy scores, immediate recall scores, and delayed recall scores than those subjects who were tested on the CFT. In addition, the encoded information would be more stable over time resulting in a greater amount of detail retained between the immediate and the delayed conditions. Although sex was not expected to affect results, results were expected to vary with age.

4.5.2 Measurement differences

The modification on the SCFT was expected to increase the specificity of the instrument. As a result, correlations between the SCFT and other memory measures in the battery were expected. These measures include the memory and localization scores on the TPT and the Visual Retention Test. The SCFT results were expected to correlate to a greater degree with the memory tests than the results from the

CFT. Some correlation was also expected between the SCFT and the L.J. Tactile Recognition Test due to the significant nonverbal component measured by the latter test (Yeudall, 1983).

Because of the organizational abilities required to analyze the figure on the CFT, significant correlations between this measure and measures of frontal lobe functioning such as the Category Test and the Wisconsin Card Sort were expected. These correlations were expected to be stronger for the CFT than the SCFT.

4.6 Analysis of hypotheses

The results of the present investigation were analyzed in two stages. First, differences between the two samples of psychiatric patients on the CFT and the SCFT as well as gender differences were assessed with a two-way analysis of variance. This analysis was applied to test for the difference in the amount of information retained between the group assessed with the CFT and the group assessed with the SCFT and if results were related to gender. Comparisons were made between the copy phase, the immediate recall phase and the delayed recall phase of both measures. A similar procedure was used by Reddon, Schopflocher, Gill, Stefanyk (in press) to compare different response formats of the Speech Sounds Perception Test.

The second stage of the analysis involved the calculation of Pearson product moment correlations between the CFT and the SCFT and the WAIS-R, the TPT, the BVRT, the HCT, and the WCST. This procedure was undertaken to determine if the CFT or the SCFT measured similar abilities as other tests used in the battery. Differences in the correlations between samples were evaluated with a Z-test (Glass & Hopkins, 1984).

4.7 Summary

The present chapter described the subjects, materials and procedures employed in the present investigation. Statistical expectations were also described. The following chapter provides a description of the actual results obtained from the analyses performed on the data.

CHAPTER 5

RESULTS

5.1 Introduction

This chapter deals with the outcomes of the statistical analyses performed on the data. Initial consideration is given to descriptions of each sample population and the similarities and differences of the group characteristics are discussed. Next, the results of the Complex Figure Test (CFT) and the Sequential Complex Figure Test (SCFT) are presented and comparisons provided. Observations concerning the effectiveness of the modified presentation to enhance encoding processes and improve retention are discussed. Finally, an examination of the correlations between the CFT and the SCFT and other neuropsychological measures provides information regarding the construct validity of the two measures.

5.2 Group Characteristics

The two sample populations were compared on age, education, IQ as measured by the Wechsler Adult Intelligence Scale-Revised, and sex. Since the groups were formed from consecutive referrals over a period of one year per group, no major differences in descriptive data were expected. The results of these comparisons are given in Tables 5.1 through 5.5.

Table 5.1
Group Characterisics for CFT and SCFT Samples

CFT Sample (N = 50)

Variable	Range	Mean	SD
Age	16-50 yrs.	31.2	9.07
Education	6-24 yrs.	11.2	3.34
IQ	72-130	89.9	11.95

SCFT Sample (N = 68)

Variable	Range	Mean	SD
Age	17-44 yrs.	27.6	6.90
Education	3-20 yrs.	11.4	3.20
IQ	65-123	89.6	13.26

The first group, assessed between April, 1987 and March, 1988, were administered the Rey-Osterrieth Complex Figure Test (CFT) plus a number of additional neuropsychological tests. Table 5.1 reveals that the group consisted of 50 subjects who ranged in age from 16 to 50 years with a mean age of 31.2 years. Their full scale IQs extended from 72 to 130 with a mean of 89.9 and the average number of years of education was 11.2 years.

The second group, assessed between June, 1988 and May, 1989 numbered 68 and ranged in age from 17 to 44 years. This group was tested with the Sequential Complex Figure Test (SCFT) and a number of additional neuropsychological tests. As seen in Table 5.1, the average IQ for the SCFT group was 89.6 with a mean of 11.4 years of education.

In Tables 5.2 and 5.3, the characteristics of age, education and IQ are presented according to the sex of the subjects. The number of males exceeded the number of females by a ratio of 2:1 in the CFT group and 5:2 in the SCFT group. Within groups, the males and females had similar IQs but the mean number of years of education was higher for females than for males. In addition, the females had a higher mean age than the males. The comparisons between males in each group revealed similar means for age, education and IQ, while comparisons of females revealed a larger mean age for the CFT group. Education and IQ for the females was the same.

Table 5.2
Group Characterisics of CFT Sample By SEX

Males (N = 33)

Variable	Range	Mean	SD
Age	16-49 yrs.	29.39	8.93
Education	6-16 yrs.	10.03	2.04
IQ	72-117	89.21	11.28

Females (N = 17)

Variable	Range	Mean	SD
Age	19-50 yrs.	24.76	8.49
Education	8-24 yrs.	13.47	4.20
IQ	74-130	91.47	13.48

Table 5.3
Group Characterisics of SCFT Sample By SEX

Males (N = 49)

Variable	Range	Mean	SD
Age	17-44 yrs.	27.26	6.69
Education	3-20 yrs.	10.94	3.22
IQ	65-123	89.22	13.57

Females (N = 19)

Variable	Range	Mean	SD
Age	17-43 yrs.	28.53	7.54
Education	7-18 yrs.	12.53	2.93
IQ	76-117	90.47	12.74

Table 5.2
Group Characterisics of CFT Sample By SEX

Males (N = 33)

In order to assess the degree to which the two groups differed on the descriptive characteristics, Age, Education and IQ x Group x Sex ANOVAs were performed. The results are presented in Tables 5.4, 5.5. and 5.6. Table 5.4 contains the results of the Age x Group x Sex ANOVA which reveals significant differences in age between groups and between sexes. Table 5.5 reveals no significant differences in IQ between groups or sexes. Meanwhile, Table 5.6 reveals significant differences in years of education between sexes but not between groups.

As a result of the significant differences in age observed between the groups, a decision was made to perform ANCOVAS on the results obtained from the CFT and SCFT to control for the effects contributed by age. These results will be presented later in the present chapter.

Before leaving the discussion of group characteristics, a brief mention will be made of the effect of the education variable in research involving adults. Because of the tremendous difficulties in equating years of education, this characteristic does not appear to be reliable. For example, three years of highschool in a vocational institution may not be equivalent to three years in a strongly academic institution. Is one year of post-secondary vocational training equivalent to one year of university? Since equivalency is almost impossible to attain, it appears to the present researcher that IQ provides a more reliable basis for comparisons from which inferences on cognitive functioning can be made. For this reason, the effect

Table 5.4

Age x Group x Sex ANOVA for Entire Population

	Source	df	Mean Squares	F	p
1.	Main Effects	2	307.586	5.09	.008*
	Age x Group	1	334.374	5.54	.020*
	Age x Sex	1	241.260	3.99	.048*
2.	Interactions	1	104.153	1.72	.192

Note 1. N: CFT = 50   SCFT = 68

Note 2. * = p < .05

Table 5.5

FSIQ x Group x Sex ANOVA for Entire Population

	Source	df	Mean Squares	F	p
1.	Main Effects	2	38.537	.235	.791
	IQ x Group	1	2.638	.016	.899
	IQ x Sex	1	72.313	.441	.508
2.	Interactions	1	6.281	.038	.845

Note 1. N: CFT = 50 SCFT = 68

Table 5.6

Education x Group x Sex ANOVA for Entire Population

	Source	**df**	**Mean Squares**	**F**	**p**
1.	Main Effects	2	73.546	7.860	.001*
	Education x Group	1	3.107	.332	.566
	Education x Sex	1	146.133	15.617	.000*
2.	Interactions	1	21.168	2.262	.135

Note 1. N: CFT = 50   SCFT = 68

Note 2. * = $p < .05$

of IQ rather than education was considered in the subsequent analyses of the data.

5.3 Encoding and Depth of Processing

The object of the present study was to evaluate and compare the abilities of the Rey-Osterrieth Complex Figure Test (CFT) and a modified version of the test, the Sequential Complex Figure Test (SCFT), to assess nonverbal memory functioning in a neuropsychological population. The modification of the test involved presenting the components of the figure in an organized, sequential fashion, in the belief that encoding of the figure in memory would be facilitated. Craik and Lockhart (1972) proposed that the coding of information into memory was the most important variable influencing its recall. According to the theory, the strength of encodings can be arranged hierarchically from superficial sensory analyses to associative analyses.

The first hypothesis to be tested in the present study was that the modified presentation of the figure would result in a stronger memory trace because component parts could be associated in an organized fashion. Therefore, significantly higher copy scores, immediate recall scores and delayed recall scores on the SCFT were predicted than on the CFT.

The hypothesis was tested by performing ANOVAs on the test results to uncover differences. The overall results of the CFT are presented in Table 5.7 and the SCFT results are presented in Table 5.8. The range, mean and standard Table

Table 5.7

Group Results on the Rey-Osterrieth

Complex Figure Test (CFT)

(N = 50) **Phase**	**Range**	**Mean**	**SD**
Copy	44-72	66.52	6.16
Immediate recall	0-62	37.96	14.87
Delayed recall	1-62	35.82	14.12
Percent savings	6-148%	91.50%	22.10%

Note: Percent savings = delayed recall/immediate recall x 100

Table 5.8

Group Results on the Sequential

Complex Figure Test (SCFT)

(N = 68) **Phase**	**Range**	**Mean**	**SD**
Copy	53-72	69.04	3.39
Immediate recall	3-65	39.50	15.11
Delayed recall	3-67	40.37	14.47
Percent savings	70-267%	106.00%	25.50%

Note: Percent savings = delayed recall/immediate recall x 100

deviation are provided for each phase of both tests. In addition, a percent savings score, based on the ratio of the delayed recall score over the immediate recall score was calculated to assess the amount of information which was retained after a delay of 45 minutes. It is assumed that the higher the percent savings score, the stronger the original memory trace since the information is retained over an extended period of time. An examination of the means on both forms of the figure test reveals higher means on the SCFT than on the CFT on all phases of the test.

The results of the CFT and the SCFT were broken down by sex of the subjects. These results are provided in Tables 5.9 and 5.10. Visual examination of these results suggests that females were differentially affected by the modification of the test, showing improvement on immediate recall, delayed recall and percent savings. The males showed a considerable improvement on the copy phase, but generally performed about the same on other phases of the test.

In order to assess the degree to which the two groups differed by sex on the copy, immediate recall and delayed recall phases of the tests and the amount of information retained after a delay of 45 minutes, ANOVAS were performed on the results. Table 5.11 contains the results of the Copy phase x Group x Sex ANOVA demonstrating significant main effects of Copy phase x Group differences but non-significant Copy phase x Sex differences. The interaction between the mean copy score and group membership and sex was not significant. More specifically,

Table 5.9

Results of the Complex Figure Test (CFT)

By Sex

Males (N = 33)

Phase	**Range**	**Mean**	**SD**
Copy	44-72	65.55	7.27
Immediate recall	9-62	40.61	14.17
Delayed recall	1-62	38.85	14.32
Percent savings	6-114%	91.00%	19.00%

Females (N = 17)

Phase	**Range**	**Mean**	**SD**
Copy	64-72	68.41	2.15
Immediate recall	0-55	32.82	15.29
Delayed recall	15-57	29.94	12.04
Percent savings	27-148%	93.00%	29.00%

Note: Percent savings = delayed recall/immediate recall x 100

Table 5.10

Results of the Sequential Complex Figure Test (SCFT)

By Sex

Males (N = 49)

Phase	**Range**	**Mean**	**SD**
Copy	56-72	69.22	2.99
Immediate recall	3-65	39.84	15.26
Delayed recall	3-67	40.41	14.91
Percent savings	70-157%	103%	15.00%

Females (N = 19)

Phase	**Range**	**Mean**	**SD**
Copy	53-72	68.58	4.32
Immediate recall	6-61	38.63	15.09
Delayed recall	16-61	40.26	13.65
Percent savings	77-267%	115%	41%

Note: Percent savings = delayed recall/immediate recall x 100

Table 5.11

ANOVA of the Copy Phase Scores for the CFT and SCFT

Source	df	Mean Squares	F	p
1. Main Effects	2	102.705	4.62	.012*
Copy Phase x Group	1	191.108	8.60	.004*
Copy Phase x Sex	1	21.834	.98	.324
2. Interactions	1	76.052	3.42	.067

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

subjects copying the figure which was presented in a sequential manner on the SCFT (M = 66.52) produced a more accurate copy than those who reproduced the figure without instructions or guidance on the CFT (M = 69.04). As predicted, these results indicate that more attention is payed to the accuracy of details of the figure during the encoding or reproduction phase when the figure is presented in a sequential manner.

Figure 5.12 reveals the results of a second ANOVA performed to assess the differences between the mean scores on the Immediate recall phase by group and by sex. Contrary to predictions, no significant differences in the immediate recall of the figure were observed. On average, short-term retention of the nonverbal material was the same whether it was presented all at once (M = 37.96) or in a sequential manner (M = 39.50). A third ANOVA, which examined the mean differences between groups and gender on the delayed recall phase, again produced no significant results. These results, which were inconsistent with predictions, can be seen in Figure 5.13. As with immediate recall of the figure, a delay of 45 minutes produced no significant mean differences between the subjects who were presented the figure as a whole (M = 35.82) and those who copied the figure sequentially (M = 40.37).

To assess differences in the average amount of information retained between the immediate recall phase and the delayed recall phase an ANOVA was once

Table 5.12

Immediate Recall (IR) x Group x Sex ANOVA
for the CFT and SCFT

	Source	**df**	**Mean Squares**	**F**	**p**
1.	Main Effects	2	250.508	1.12	.329
	IR x Group	1	47.56	.21	.645
	IR x Sex	1	432.681	1.94	.166
2.	Interactions	1	266.775	1.19	.276

Note 1. N: CFT = 50   SCFT = 68

Table 5.13

Delayed Recall (DR) x Group x Sex ANOVA
for the CFT and SCFT

	Source	df	Mean Squares	F	p
1.	Main Effects	2	506.464	2.52	.085
	DR x Group	1	530.448	2.64	.107
	DR x Sex	1	417.032	2.08	.152
2.	Interactions	1	473.452	2.36	.128

Note 1. N: CFT = 50   SCFT = 68

again performed on the Percent Savings score calculated for each subject. This analysis reveals significant differences between groups but not between sexes. No significant interaction between the mean percent savings score and group membership and gender occurred. The results of this analysis are provided in Figure 5.14. Although there were no significant mean differences in the immediate recall phase and the delayed recall phase between groups, the amount average amount of information retained by each subject differed significantly. Subjects who copied the figure in a sequential manner appeared to encode the information in a more permanent fashion than subjects who copied the figure directly. Gender of the subject had no effect on performance.

The percent savings score provided some unexpected results worth noting. On both the CFT and the SCFT, many subjects produced a better copy of the figure in the delayed condition than in the immediate recall condition but this occurred with greater regularity and to a greater degree on the SCFT. The percent savings score ranged from 6% to 148% on the CFT (M =91.5%) and from 70% to 267% on the SCFT (M = 106%) (see Figures 5.7 and 5.8). It appears that a delay period may be helpful in consolidating nonverbal information making it more accessible to retrieval. This phenomenon will be discussed at greater length in Chapter 6.

Table 5.14

Percent Savings (PS) x Group x Sex ANOVA
for the CFT and SCFT

	Source	df	Mean Squares	F	p
1.	Main Effects	2	.379	6.56	.002*
	PS x Group	1	.657	11.38	.001*
	PS x Sex	1	.133	2.29	.132
2.	Interactions	1	.052	.89	.346

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

5.3.1 The Effects of Age and IQ

As mentioned earlier, significant differences in age between groups were observed. Since age is also related to IQ as measured by the Wechsler Adult Intelligence Scale-Revised, further analysis of the data, controlling for these effects was undertaken. ANCOVAs, similar to the four ANOVAs discussed above, were performed using age and IQ as covariates.

A Copy phase x Group x Sex ANCOVA with age and IQ as covariates was carried out on the scores obtained from the copy phase of both the CFT and the SCFT. The results, presented in Table 5.15, reveal significant differences between groups when the variance of IQ is controlled for but the variance contributed by age is not a significant factor. The ANCOVA on the Copy phase scores yields similar results to those obtained from the ANOVA where subjects assessed on the SCFT produced a significantly more accurate reproduction than subjects who were assessed with the CFT.

Once the effects of age and IQ were controlled for, a significant Copy Score x Group main effect was observed. Figure 5.1 illustrates that the significance is derived from the superior performance by males in copying the figure on the SCFT as compared to the performance by males on the CFT. The female scores did not differ from one condition to the other.

Although the covariates of age and IQ contribute a significant degree of Table

Table 5.15

Copy Phase(CP) x Group x Sex ANOVA for the CFT and the SCFT with Age and IQ as covariates

	Source	df	Mean Squares	F	p
1.	Covariates	2	257.997	14.20	.000*
	Age	1	13.081	.72	.398
	IQ	1	512.817	28.23	.000*
2.	Main Effects	2	96.129	5.29	.006*
	CP x Group	1	182.719	10.06	.002*
	CP x Sex	1	11.655	.64	.425
3.	Interactions	1	72.368	3.984	.048*

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

Figure 5.1 Interaction Between Group Membership and Sex.

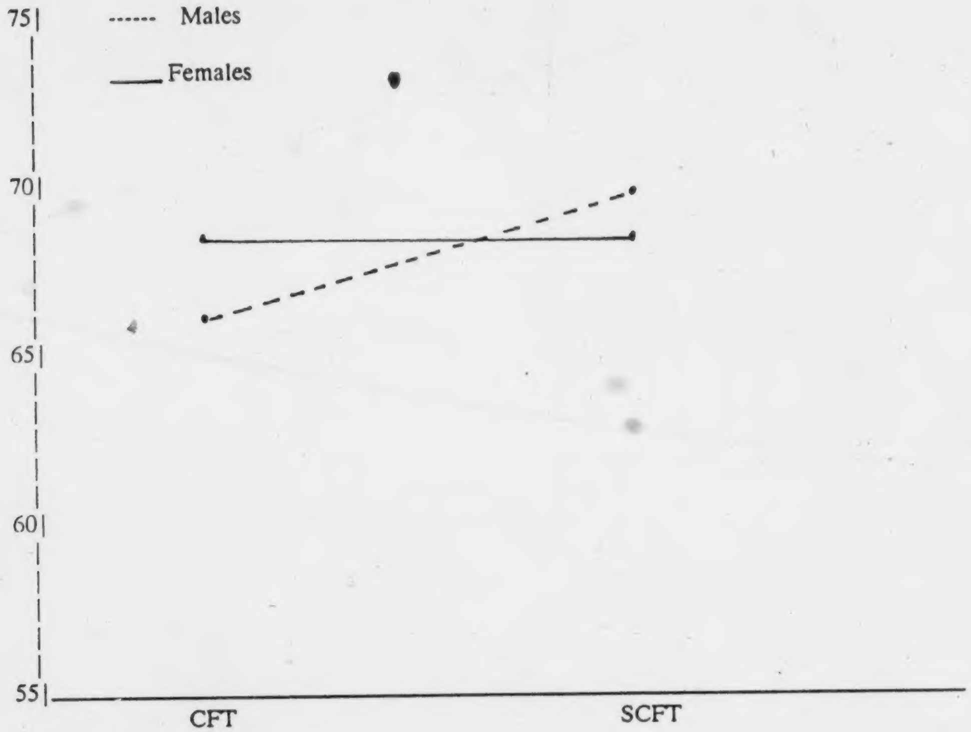

Figure 5.1 Mean copy phase score as a function of group membership and sex following ANCOVA with age and IQ as covariates.

Note: CFT = Complex Figure Test; SCFT = Sequential Complex Figure Test.

variance to the performance of subjects on the Immediate recall phase and the Delayed recall phase, partialling out their effects did not produce significant main effect or an interaction in either condition. Tables 5.16 and 5.17 display the results of the ANCOVAs which reveal no significant main effects or interactions when the effects of age and IQ are held constant. These results are contrary to predictions that the sequential format of the SCFT would result in higher immediate and delayed recall scores than those obtained on the CFT.

The final ANCOVA, performed on the Percent Savings scores, reveals that age and IQ do not contribute a significant degree of variance to the main effect observed between the groups. Table 5.18 reveals significant main effects between groups but not between sexes on the Percent Savings score. These results suggest that the greater degree of information retained on the SCFT as compared to the CFT can be attributed to the sequential presentation of the component parts of the figure and not to age or to IQ. These results are consistent with the prediction that an organized, sequential presentation of the nonverbal material will result in more complete retention of the data.

5.4 Measurement Validity

The strength of the hypothesized relationship between the SCFT and other nonverbal memory measures including the memory component of the TPT and the

Table 5.16

Immediate Recall(IR) x Group x Sex ANOVA
for the CFT and the SCFT
with Age and IQ as Covariates

	Source	**df**	**Mean Squares**	**F**	**p**
1.	Covariates	2	3159.428	18.356	.000*
	Age	1	1172.307	6.811	.010*
	IQ	1	6052.356	35.163	.000*
2.	Main Effects	2	199.564	1.159	.317
	IR x Group	1	1.666	.010	.922
	IR x Sex	1	395.988	2.301	.132
3.	Interactions	1	203.574	1.183	.279

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

Table 5.17

Delayed Recall(DR) x Group x Sex ANOVA
for the CFT and the SCFT
with Age and IQ as Covariates

	Source	**df**	**Mean Squares**	**F**	**p**
1.	Covariates	2	3443.211	23.447	.000*
	Age	1	1537.172	10.468	.002*
	IQ	1	6452.881	43.943	.000*
2.	Main Effects	2	335.977	2.288	.106
	DR x Group	1	280.465	1.910	.170
	DR x Sex	1	375.430	2.557	.113
3.	Interactions	1	383.717	2.613	.109

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

Table 5.18

Percent Savings (PS) x Group x Sex ANOVA for the CFT and the SCFT with Age and IQ as Covariates

	Source	**df**	**Mean Squares**	**F**	**p**
1.	Covariates	2	.006	.105	.900
	Age	1	.007	.113	.737
	IQ	1	.009	.147	.702
2.	Main Effects	2	.375	6.394	.002*
	PS x Group	1	.640	10.906	.001*
	PS x Sex	1	.121	2.066	.153
3.	Interactions	1	.055	.940	.334

Note 1. N: CFT = 50 SCFT = 68

Note 2. * = $p < .05$

BVRT was assessed through calculations of Pearson correlations between the scores on the CFT and SCFT and those obtained from the TPT and the BVRT. It was also hypothesized that the SCFT would correlate with fewer measures than the CFT because of the greater specificity of the measuring instrument.

The results of the correlations are provided in Tables 5.19 and 5.20. As predicted, the SCFT correlates significantly with the memory and localization scores on the TPT ($p < .01$) and the total error scores on the BVRT ($p < .001$). The CFT scores showed no significant correlations with the memory and localization scores of the TPT. The copy scores and the delayed recall scores of the CFT correlated with the total error scores of the BVRT, although to a lesser degree than those observed with the SCFT. These results suggest that the SCFT may be a more valid measure of nonverbal memory than the CFT if assumptions regarding the validity of the TPT and the BVRT in the literature are correct.

Consistent with predictions, the SCFT correlated significantly with results of the LJTR while the CFT showed no significant correlations with the test. Since the LJTR is a putative measure of nonverbal abilities but has no memory component, the results suggest that the SCFT may share this characteristic while the CFT may not.

Both the SCFT and the CFT had strong correlations with the WAIS-R. It appears that between 20 and 25 percent of the variance in these measures is Table

Table 5.19
Pearson Correlations between the Copy phase, Immediate Recall phase, Delayed Recall phase and Percent Savings for the CFT and Neuropsychological Tests

Neuropsychological Tests	Copy	IR	DR	PS
Wechsler Adult Intelligence Scale-Revised				
1. Verbal IQ	.5023**	.2772	.3654*	.2518
2. Performance IQ	.4341**	.4872**	.4341**	.0780
3. Full Scale IQ	.5014**	.3902*	.4228*	.1859
Tactual Performance Test (TPT)				
1. Total time	-.0537	-.3062	-.3424*	-.1337
2. Memory	.1407	.2646	.2171	.0905
3. Localization	-.0582	.2674	.2809	-.0420
Benton Visual Retention Test (BVRT)				
Total errors	-.4901**	-.2892	-.4060*	-.2273
Halstead Category Test (HCT)				
Total errors	-.2327	-.3668*	-.3609*	-.0478
Wisconsin Card Sorting Test (WCST)				
1. Total errors	-.1308	-.1343	-.0600	.0321
2. # of subtests	.0814	-.1329	-.0659	.1437
L.J. Tactile Recognition Test (LJTR)				
1. Total time	-.0979	-.2402	-.2670	-.0869
2. Total errors	-.1728	-.0735	-.2190	-.4294*

Note 1. * = $p < .01$
** = $p < .001$
Note 2. IR = Immediate recall
DR = Delayed recall
Ps = Percent savings
Note 3. Percent savings = Delayed recall/Immediate recall X 100.

Table 5.20
Pearson Correlations between the Copy phase, Immediate Recall phase, Delayed Recall phase and Percent Savings for the SCFT and Neuropsychological Tests

Neuropsychological Tests	Copy	IR	DR	PS
Wechsler Adult Intelligence Scale-Revised (WAIS-R)				
1. Verbal IQ	.4024**	.3428*	.3800**	.0020
2. Performance IQ	.4110**	.5376**	.5620**	-.0752
3. Full Scale IQ	.4289**	.4807**	.5121**	-.0499
Tactual Performance Test (TPT)				
1. Total time	-.5850**	-.4953**	-.5399**	.0015
2. Memory	.3003*	.3757**	.4007**	-.0078
3. Localization	.4193**	.5396**	.5860**	.0860
Benton Visual Retention Test (BVRT)				
Total errors	-.5042**	-.5843**	-.6413**	.0275
Halstead Category Test (HCT)				
Total errors	-.4505**	-.5432**	-.5948**	.0281
Wisconsin Card Sorting Test (WCST)				
1. Total errors	-.4482**	-.2831*	-.3669*	-.1295
2. # of subtests	.3304*	.2334	.2709	.0800
L.J. Tactile Recgnition Test (LJTR)				
1. Total time	-.4044**	-.5214**	-.5707**	-.0898
2. Total errors	-.4486**	-.2815	-.3225*	-.0776

Note 1. * = $p < .01$
** = $p < .001$

Note 2. IR = Immediate recall
DR = Delayed recall
PS = Percent savings

Note 3. Percent savings = Delayed recall/Immediate recall X 100.

Table 5.21
Significant Differences Between Correlations of the CFT and the SCFT and other Neuropsychological Measures

Neuropsychological Tests	Copy	IR	DR	PS
Wechsler Adult Intelligence Scale-Revised				
1. Verbal IQ				
2. Performance IQ				
3. Full Scale IQ				
Tactual Performance Test (TPT)				
1. Total time	*			
2. Memory				
3. Localization	*	*	*	
Benton Visual Retention Test (BVRT)				
Total errors		*	*	
Halstead Category Test (HCT)				
Total errors			*	
Wisconsin Card Sorting Test (WCST)				
1. Total errors	*		*	
2. # of subtests				
L.J. Tactile Recognition Test (LJTR)				
1. Total time	*	*	*	
2. Total errors	*			**

Note 1. * = $p < .05$
** = $p < .01$
Note 2. IR = Immediate recall
DR = Delayed recall
Ps = Percent savings
Note 3. Percent savings = Delayed recall/Immediate recall X 100.

accounted for by IQ. Contrary to predictions, the SCFT correlated strongly with the HCT and the WCST while no significant correlations between the CFT and the WCST were observed. Weaker correlations between the CFT and HCT were detected. These results indicate that the hypothesis proposing greater specificity of the SCFT cannot be accepted. It appears that a greater number of cognitive functions are involved in the encoding and retrieval of the figure on the SCFT than on the CFT.

5.5 Summary

In summary, it can be construed from the results in this chapter that the hypotheses of the study were partially upheld. Thus, contrary to predictions, significant differences between the immediate recall scores and the delayed recall scores on the SCFT and the CFT were not observed. Predicted differences did occur between the copy scores with significantly better results obtained on the SCFT. Also consistent with predictions, the amount of information retained after a delay was greater on the SCFT than on the CFT suggesting better initial encoding of the stimuli. The observed significant sex differences on the copy phases of the CFT and the SCFT were not expected.

Regarding the validity of the measures, the predicted higher correlations between the SCFT and other nonverbal measures was observed while the CFT did not correlate with these measures. Contrary to predictions, the SCFT did not demonstrate greater specificity, since significant correlations with a number of neuropsychological measures were obtained.

CHAPTER 6

Discussion

6.1 Introduction

This chapter begins with an integration of the findings of the study. An exploration of the relevant implications of these results to theory is presented next, followed by a discussion of the limitations of the research. Suggestions for future research are then presented and the chapter concludes with a comment on the relevance of these findings for practitioners.

6.2 Integration of Results

The present study examined the retention and retrieval of nonverbal stimuli by subjects in a psychiatric setting. Two presentations of the Complex Figure Test were compared. In the Rey-Osterrieth version of the test (CFT), the entire figure was presented as a whole while in the modified version (SCFT), each component of the figure was presented individually. It was hypothesized that subjects would form spatial associations between component parts of the figure on the SCFT much more readily than on the CFT, resulting in deeper, more permanent encoding of the stimuli. The hypothesis evolved from the levels of processing approach proposed by Craik and Lockhart (1972) for verbal stimuli.

The levels of processing view stresses the qualitative differences in the operations that occur at encoding and suggests that the strength of the memory trace is a function of the orienting task employed by the subject (Craik & Lockhart, 1972). Furthermore, the processing of information could be hierarchically arranged from superficial sensory analysis through to a more associative type of analysis. The probability of retention is directly related to the depth of processing. This view is a departure from the flow charting and "boxes" conceptualization of memory which stresses the passage of information from one store to another as proposed by Atkinson and Schiffrin (1968).

In the present study, four separate scores were calculated for each subject on both the CFT and the SCFT. These include a copy score which describes the quality of the reproduction during the learning phase, an immediate recall score obtained on the immediate reproduction of the figure from memory, a delayed recall score obtained 45 minutes after original presentation and a percent savings score. The latter is a ratio score viewed as the percentage of information retained after a delay. Each of these are discussed separately in the following section

6.2.1 The Copy Phase

The significantly higher mean copy score obtained on the SCFT demonstrated, as predicted, that a better reproduction of the figure is obtained when component parts are presented sequentially. Careful examination of these results reveals that males only were responsible for the significant differences obtained on the SCFT. The means obtained by the females were almost identical on both measures (CFT = 68.41; SCFT = 68.58), while the mean for males on the SCFT was significantly better than on the CFT. These results were unexpected.

Several explanations may account for this finding. First, in both groups, the number of females was small, producing results with low reliability. Second, the males involved in the present study typically suffered from organic brain dysfunction due to substance abuse or accidental head injuries. Females, on the other hand, were most often diagnosed as depressed or schizophrenic. Sequential presentation of the stimuli precluded the need to program an approach to copying the figure which appears to simplify the task. The simplification may be of greater benefit to subjects suffering from organic disorders than those suffering from psychiatric disorders.

A final explanation concerns the manner of presentation of the stimuli and its relationship to the form of information processing involved in performing the task. Luria (1966) distinguished two types of information processing: simultaneous and successive processing. Simultaneous synthesis involves the organization of information in a spatial-like manner. That is, each unit of information is immediately available in relation to other units. Successive processing involves the organization of information into a sequential scheme. Das, Kirby and Jarman (1979) proposed that the type of information processing selected depends on the individual's preferred mode of processing which in turn is influenced by experimental, sociocultural, and genetic factors. Task demands and the interaction between preferred mode and task demands also contribute to the selection of a processing mode. Forcing the use of sequential processing may have a differential effect on males and females, with greater advantage for males. A more thorough investigation of cognitive processes involved in reproducing the complex figure, based on Luria's model, may provide insight into gender differences in cognitive functioning.

6.2.2 The Immediate Recall Phase

The results of the immediate recall phase indicate that the form of presentation of the complex figure produced no significant differences on the short-term retention of the figure. Thus subjects who had the opportunity to carefully integrate each component of the figure, in a sequential, structured manner, did not retain more information, immediately after removal of the stimulus, than those who were given the entire figure at once. This finding provides support for the Hasher and Zachs (1979) proposition regarding effortful and automatic attentional operations. The proposition states that spatial and temporal aspects of stimuli are encoded automatically and paying attention to information which is otherwise encoded automatically does not improve on the encoding of that information. In the present study, greater attention was drawn to each component of the complex figure by the individual presentation of each component, but this manoeuvre did not improve on the immediate retrieval of the stimuli.

Of significance to the present discussion is the fact that the immediate recall phase of the test comes as a surprise to the subject. Upon completion of the copy phase, the stimulus is removed and the subject is then asked to reproduce the figure from memory. This procedure impacts on the results obtained on the immediate recall phase.

First, subjects typically experience some anxiety when they are informed of the recall phase. The anxiety subsides quickly in most subjects as they begin to recall the figure. A few subjects cannot overcome the anxiety and perform poorly at this stage. Second, observation of the subjects' performance reveals that this phase is an active learning phase whereby the subjects are mentally rehearsing the information in order to retain it. Evidence of this comes from the verbalizations of patients as they attempt to reproduce the figure. Many subjects provided verbal labels for component parts of the figure regardless of which test form was used. These observations suggest that subjects tended not to initiate the mental processes which store information and require a greater allocation of mental resources until the need arose. Processing information for retention appears to be a deliberate activity initiated by the individual. Clinical implications of this observation are discussed later in this chapter.

6.2.3 The Delayed Recall Phase

Contrary to predictions, significant differences were not obtained between groups on the delayed recall phase of the test although the differences approached significance (p = .085). Indications of a relationship between initial encoding of non-verbal information and its long-term retention and retrieval are present. Of greatest significance is the finding that many subjects tested on the SCFT had higher delayed recall scores than immediate recall scores. In other words, long-term retention was better than short-term retention.

This finding provides support for the concept of consolidation as proposed by Squire, Cohen, and Nadel (1984). Consolidation refers to the idea that memory storage does not occur instantaneously but instead develops after initial learning. That is, the original representation of stimuli can change with time. This hypothesis was stated many years ago (1903) by Burnham, who stated that representations in long-term memory are affected by subsequent external events, such as repetition and other acquired information, and by internal events, such as rehearsal and efforts at reconstruction.

Squire, Cohen and Nadel (1984) have proposed a neurobiological concept of consolidation. They suggest that at the time of learning, the medial temporal region establishes a functional relationship with memory storage sites, especially in the neocortex. The medial temporal region then performs a time-limited function of maintaining the organization of distant memory storage sites until such time as the coherence of these sites increases and they can be activated without the participation of the temporal region. These storage sites are responsible for remote memories which have proven to be durable even in the presence bilateral temporal lobectomies (Scoville and Milner, 1957). The process of consolidation begins immediately after initial learning and may continue for a period of two to three years.

In a very recent article, Alkon (1989) has provided evidence for the concept of consolidation by observing electrical and molecular changes in nerve cells during associative learning in rabbits and snails. Alkon and his colleagues have demonstrated that the potassium-ion flow in the hippocampal cells of the rabbit is reduced after learning has occurred, increasing the excitability of the cell. This only occurs with associative-type learning and not during sensitization or habituation. The reduction of the potassium-ion flow lasts not just for seconds, minutes or hours but for many days and probably much longer. In the snail, the potassium-ion current changes brought on by conditioning are easily observed because of the small number of neurons and their well-characterized connections. A causal relationship between the potassium-ion current changes and the storage and potential recall of the learned association has been established in these simple organisms (Alkon, 1989).

The results of the present study provide support for the concept of consolidation. The immediate recall phase of both the CFT and the SCFT appeared to be an attempt at reconstructing the figure, with the deliberate intention of processing the stimuli for storage. Reconstruction of the figure appeared to be effective, in the long-term, for the subjects who had copied the figure in a sequential manner. The improved scores on the delayed recall phase suggest that deliberately processing information for storage resulted in more durable memory traces and that processing continued for some time.

6.2.4 The Percent Savings Score

The percent savings score was calculated as a measure of the amount of information retained after a delay period. It was hypothesized that those subjects who learned the complex figure in a sequential manner, which allowed for the integration of each component part of the figure would retain more information than those who received the entire figure at once. The significant differences between the means of the group suggest that storage of information on the SCFT was more permanent than information storage on the CFT. In fact, as discussed above, more information was recalled in the delayed phase than in previous phases resulting in a mean percent score which is well over 100%.

These results are inconsistent with the information processing view of memory (Atkinson & Shiffrin, 1968) which proposes that information is transferred from one form of memory storage to another. According to this view, only information which is repeatedly rehearsed and maintained in short-term memory is transferred to long-term memory. The present results suggest that rehearsing may be but one process which is initiated once information is processed for storage. Other implicit processes may be involved. The manner of presentation of information appears to determine the quality of information processing which is more in keeping with the levels of processing view proposed by Craik and Lockhart (1972).

6.2.5 Summary

In summary, the comparison of the CFT and the SCFT reveals several significant findings. First, the sequential presentation of the figure on the SCFT resulted in a better original reproduction of the stimulus figure. Second, the manner of presentation had no significant effect on immediate recall, but a tendency for improved delayed recall of the figure was evident. Finally, subjects tested on the SCFT recalled more information after a delay than the subjects tested on the CFT.

6.3 Interpretation of Correlational Data

To determine if the modification of the Complex Figure Test altered its validity, both the CFT and the SCFT were correlated with a number of neuropsychological measures. A number of results are relevant to the present discussion.

First, both forms of the test correlate with the Verbal, Performance, and Full scale IQs on the WAIS-R. General intelligence accounts for approximately 20% of the variance obtained from the non-verbal memory tests. Subtle differences nevertheless do exist. The highest correlation between the WAIS-R and the CFT occurred on the copy phase and more specifically, with verbal IQ. It appears that in programming an approach to copying the figure on the CFT, subjects may be using verbal mediators. In contrast, the highest correlation between the SCFT and the WAIS-R occurred between the delayed recall phase and performance IQ. This result is more in keeping with expected findings from a putative measure of non-verbal memory.

The Benton Visual Retention Test (BVRT) is a widely accepted measure of non-verbal memory. High correlations between this measure and the CFT and SCFT were expected. The SCFT demonstrated considerably stronger correlations with the BVRT than did the CFT. This finding suggests that the modification of the Complex Figure Test not only maintains its construct validity but indeed enhanced it. Similar results were obtained with the Tactual Performance Test (TPT) where the SCFT correlated with total time, memory and localization while the CFT correlated only with total time. The SCFT also correlates with the L.J. Tactile Recognition Test (LJTR), recognized for its nonverbal characteristics, while the CFT did not. In sum, it appears that the modified presentation of the test is a stronger measure of spatial and memoral abilities than its original version. The validity of the SCFT as a measure of nonverbal memory is upheld.

Contrary to predictions, correlations between the SCFT and measures of frontal lobe functioning including the Halstead Category Test (HCT) and the Wisconsin Card Sorting test (WCST) were observed. Sequencing the component parts of the figure was expected to preclude the programming of an approach to copying the figure, an ability associated with frontal lobe functioning (Pillon, 1981) and consequently, correlate less with the Halstead Category Test.

Both the immediate and delayed recall sores of the CFT and the SCFT correlated significantly with the HCT, but the correlation was significantly stronger on the delayed recall phase of the SCFT. Approxiamtely 35% of the variance in the delayed recall scores on the SCFT was accounted for by the HCT. The HCT has a visuospatial component correlating most highly with the Block Design and Picture Arrangement subtests of the WAIS-R and also requires effective learning skills (Lezak, 1983). The correlation between the HCT and the SCFT may be explained by the strong correlations observed between the SCFT and the Performance IQ on the WAIS-R.

The work of Smith and Milner (1984) provides a plausible explanation for the above findings. They have found that any memory task that requires the learning of a large list of similar items involves frontal lobe functioning. Patients with frontal lobe lesions were found to be impaired in recalling the names of 16 recently presented toy objects, even though they could remember the original locations of the objects as well as normals when presented with the object. Subjects in the present study were required to recall 18 individual components to complete the figure correctly. Milner (1963) has also demonstrated that frontal lobe patients could not succeed on the WCST because their lesions caused perseveration and the loss of flexibility. These impairments would also interfere with the recall and reproduction of a large number of similar items stored in memory.

The findings of the present study provide support for the involvement of frontal lobes in some memory functions. Frontal lesions do not appear to produce any straightforward, general memory impairment but they can influence the performance on memory tests.

6.4 Implications for Memory Theory

Two major theories of memory functioning were reviewed in the present study: the information processing model and the depth of processing model. The former stresses rehearsal as the mechanism for transferring information from short-term to long-term memory while the latter emphasizes the number and quality of processes performed on the stimuli to account for its long-term retention. The present study demonstrates that the type of processes which occur at encoding impact directly upon retrieval processes, at least for subjects in a psychiatric setting. This view is consistent with the depth of processing model proposed by Craik and Lockhart (1972).

The basic notions of the levels of processing framework are that the episodic memory trace is a by-product of the operations carried out by the cognitive system and that the strength of the trace is a function of "depth" of processing, where depth refers to greater degrees of semantic involvement (Craik & Tulving, 1975). Minimal semantic analysis, according to this view, is more beneficial than extensive structural analysis. This theory has been used to describe the verbal memory system in terms of its constituent operations and processes, but has rarely been applied to non-verbal memory processes.

As discussed in chapter II, a body of evidence has favoured the view that, after a period of time, information is represented in an abstract, propositional code that is not tied to the sensory modality through which it is presented (Norman & Rummelhart, 1975). Thus the dual coding theory proposed by Paivio (1971) which holds that information is represented primarily as visual images and verbal memories, has not been supported. In view of this, it would follow that processing information for retention requires the transformation of the meaning of events into abstract codes for storage. This would relate to both verbal and non-verbal information.

Semantic analysis is an appropriate description of the deep processing of verbal information described by Craik and Tulving (1975), but what of the abstract coding of non-verbal stimuli? Can it also be referred to as "semantic analysis"? The present investigation indicates that, just as with verbal information, non-verbal stimuli can be processed in different degrees or depths depending upon the type of cognitive processing performed by the subject. The results of this study suggest that the manner of presentation of the stimulus may even affect the formation of abstract codes for more permanent storage. This finding is consistent with the proposition reported in chapter II that compatibility between encoding and retrieval processes is crucial to effective memory functioning (Fisher & Craik, 1977).

Rather than refer to "semantic analysis" for the deep processing of non-verbal stimuli, the term "associative coding" of information might be used to refer to this function. The semantic processing of verbal material has been described as the deepest, most abstract form of processing. Although the cognitive processes may be the same in the processing of verbal and non-verbal stimuli, the term semantic analysis does not relate as well to non-verbal memory. The writer suggests that "associative processing" would be a more appropriate expression for deep processing of both verbal and non-verbal stimuli.

The term associative processing was selected since it appears to most closely describe the function involved in the formation of abstract codes for storage. Alkon (1989) has recently investigated memory storage at the molecular level. When unconditioned or unassociated stimuli were presented to their laboratory animals, they elicited reproduceable electrical and ultimately behavioral outputs. Since memory was not involved, the input information would simply flow through the neural pathways that were genetically determined. When an unconditioned stimulus was temporally associated with a conditioned stimulus, the electrical output flowed along a new pathway that was not genetically determined. In tracing the formation of associative memory in the animals, Alkon observed changes in the structure of the neuronal architecture and concluded that neurons involved in memory storage are dynamic. Although they are no longer capable of dividing, they are capable of dramatic transformations which occur in different time domains (seconds, days and longer) and in different spatial domains within the cell. These changes only occurred during the formation of discrete associations.

Associative processing can be applied to the behaviors observed in the present study. The sequential presentation of the components of the complex figure on the SCFT emphasized the spatial relationship of one component to the other, thereby facilitating the formation of associations between components. Presenting the figure as a whole, as was done on the CFT, does not insure that subjects will analyze the figure to the same degree. The formation of associations, according to Alkon (1989) is the key to memory storage. Associative processing can be readily applied to verbal memory processing as well, since semantic processing requires the association of a stimulus to an existing meaning. Regardless of the modality used in acquiring the information, the essence of processing information for storage appears to be the formation of associations which can be facilitated by environmental manipulations.

In concluding the discussion on theoretical implications of the present study, it is interesting to return to early theoretical formulations concerning memory functioning. At the turn of the century, associationists proposed that sensations which were contiguous would be come associated. This belief eventually led to the theories of stimulus and response which emphasized sequential dependencies between associations formed through the contiguous presentation of stimuli. Neuronal research is demonstrating that contiguity is a necessary but not sufficient condition in the formation of memory traces. In contrast to the associationists view, an association in the present discussion refers to the alteration, in some manner of a pre-existing abstraction. The crucial element of this viewpoint is that it actively involves the person in the processing of information.

6.5 Relevance to Clinical Practice

As discussed in chapter III, the entire field of memory testing has come under recent scrutiny and criticism (Loring & Papanicolaou, 1987; Richardson-Klavehn & Bjork, 1988). Clinicians appear to be experiencing increasing difficulty interpreting the results of standard measuring instruments such as the Wechsler Memory Scale. Perhaps the whole approach to memory testing should be re-evaluated in light of the many recent neurophysiological findings.

Two major reasons justify the clinical assessment of memory functioning: diagnosis and remediation. As reviewed in chapter III, memory impairments have largely been associated with compromised temporal lobe functioning. Diseases such as epilepsy and Alzheimer's disease or abnormalities such as tumors often result in significant memory impairments. Assessing more specific aspects of memory functioning such as encoding style may provide clues useful in the differential diagnosis of certain disorders.

Memory also appears to be mediated by some areas of the diencephalon. This is most clearly observed with Korsakoff's disease and following infarcts affecting that particular brain region. Research has demonstrated that the memory impairments associated with the diencephalon differ from those observed with temporal lobe disease. Using memory tests like the SCFT which provide overt encoding strategies, would provide more accurate information about the memory deficits associated with each brain region.

Accurate assessment also impacts upon remediation strategies. Some psychiatric patients cannot benefit from remediation but for many suffering from functional psychiatric disorders, specific mnemonic strategies can improve the quality of their day to day functioning. By examining encoding and retrieval processes specifically rather than viewing memory as a unitary function, more precise remediation strategies can be developed to compensate for defecits.

The results of the present study suggest that greater attention should be given to the manner in which stimuli are presented for encoding on memory tests. Presenting the to-be-remembered material in a manner which requires transformations or organization prior to encoding, makes it difficult to attribute errors to memory impairments. When the procedures used to encode stimuli are explicit on memory measures, more valid results are obtained leading to greater accuracy in diagnosis and more appropriate remediation.

Findings from the present study suggest that although the SCFT leads to better retention of mewly learned nonverbal material in a psychiatric population, it also requires more concentration than does the CFT. Therefore, the SCFT may not be useful with all populations. Individuals who cannot attend to a task for long periods of time such as those suffering from bipolar depression, may perform poorly on the SCFT. The CFT may be more useful with these patients.

6.6 Future Research

Given that the evidence from this study suggests that within a psychiatric population, cognitive processes involved at the encoding of nonverbal stimuli have a direct relation to the ability to retrieve the stimuli from memory, the most obvious implication for future research is the investigation of this phenomenon within a normal population using the SCFT. Particular attention needs to be paid to gender differences in processing nonverbal data since males were significantly better at reproducing the complex figure when the individual components of the figure were presented sequentially.

In addition, the ability of the SCFT to differentiate disorders which are typically associated with memory defecits, should be evaluated. The SCFT is particularly well-suited to examining nonverbal memory functioning because of its many phases. In addition to perceptual and constructional abilities, the test measures immediate recall, delayed recall and provides a measure of the percentage of information retained over time. Populations can be compared on numerous aspects of memory.

Finally, subjects in the present study were not informed, prior to the presentation of the figure, that their memory of it would be assessed. Having that knowledge may have some effect on the manner in which the figure is mentally encoded and either enhance or impair the retrieval of the figure. Deliberate and incidental storage of nonverbal information may produce significantly different results, or as Hasher & Zacks (1979) have suggested, have no bearing on the coding of spatial information. This information would add greatly to our present understanding of memory functioning.

In conclusion, the author wishes to draw attention to the importance of viewing memory as a multifaceted cognitive function. Elucidating the numerous processes involved in the encoding, storage, and retrieval of information will result in more valid and reliable assessment of these essential human functions. The combination of neuropsychological and neurophysiological research data may even lead to the successful treatment of memory impairments in the future.

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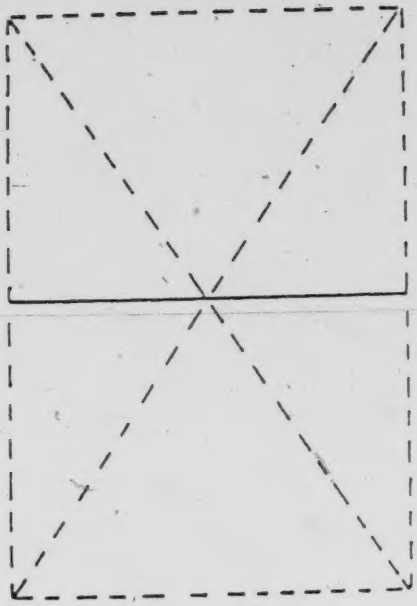
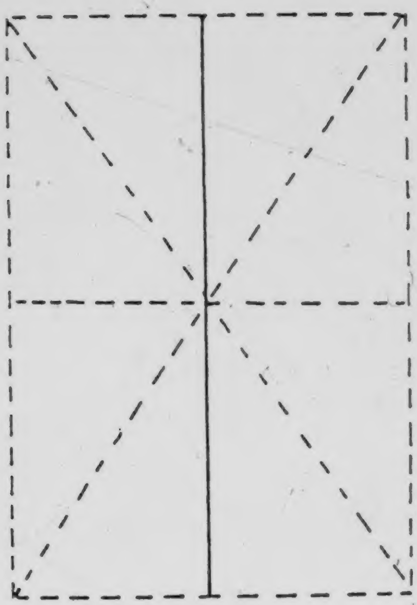
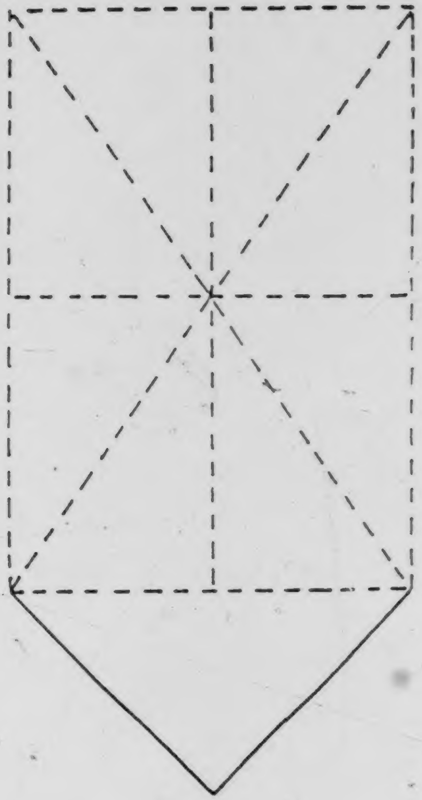
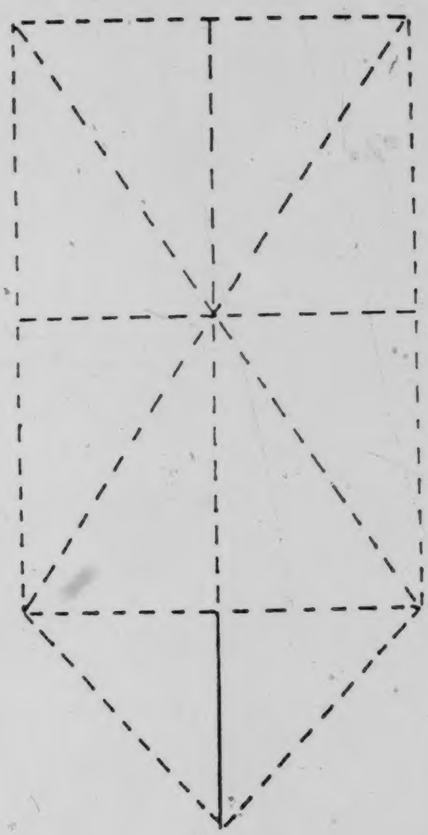
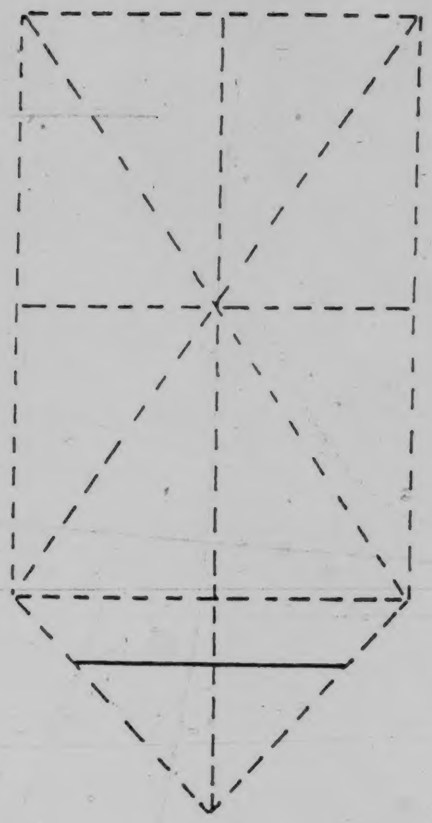
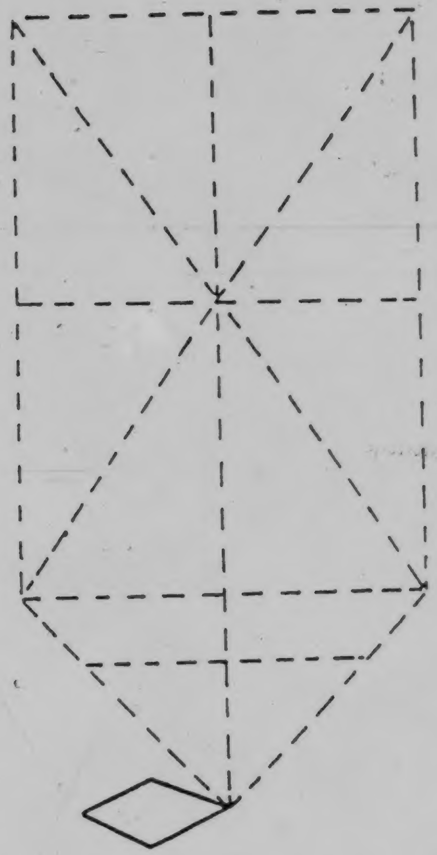
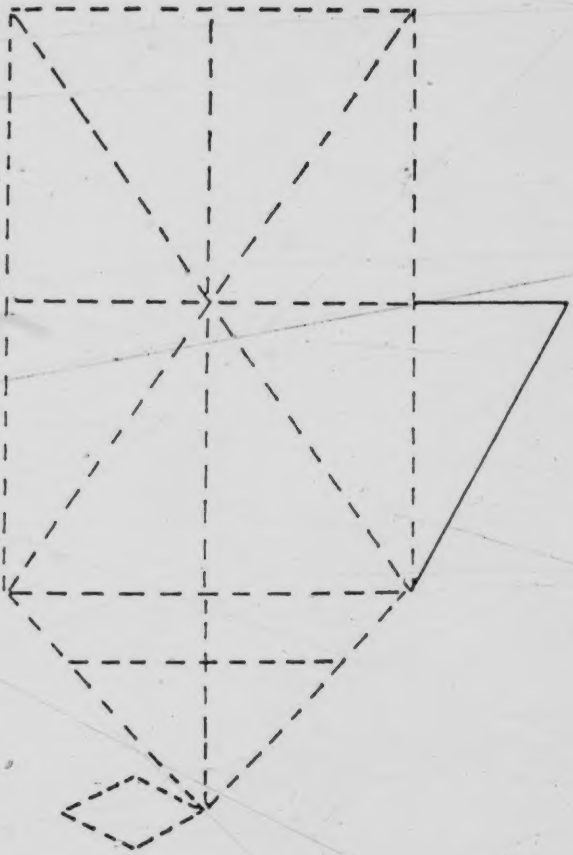
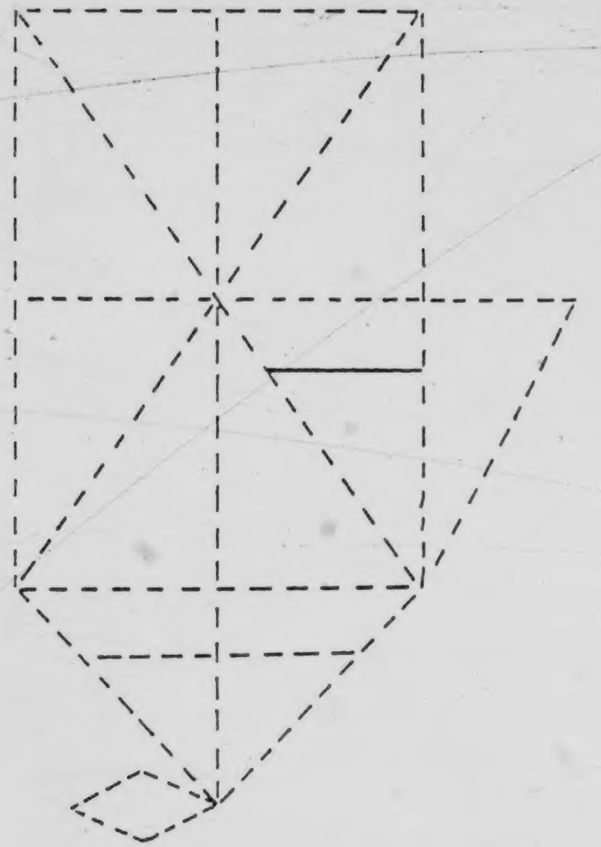
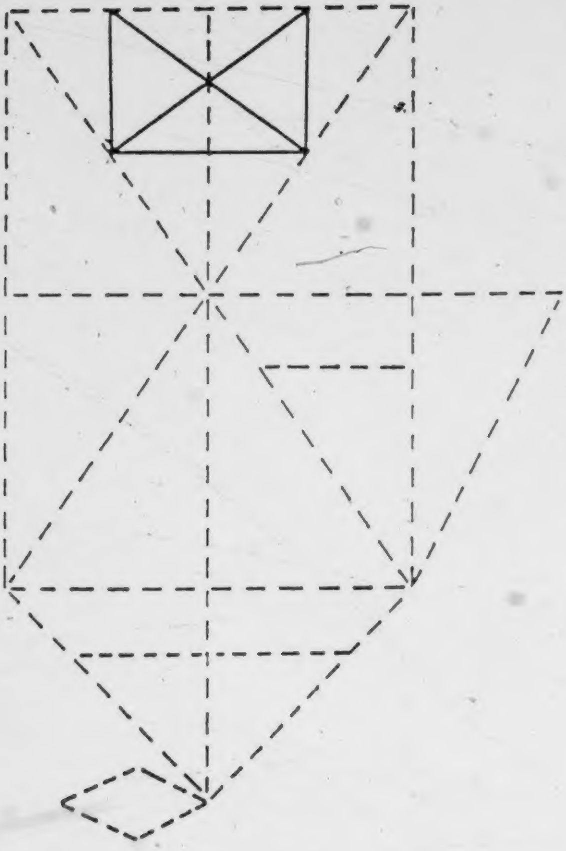
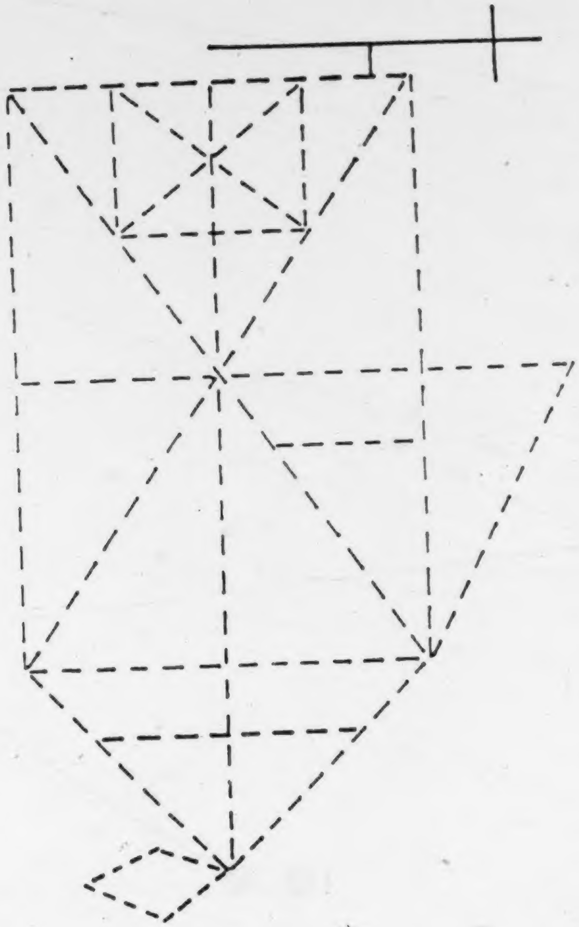
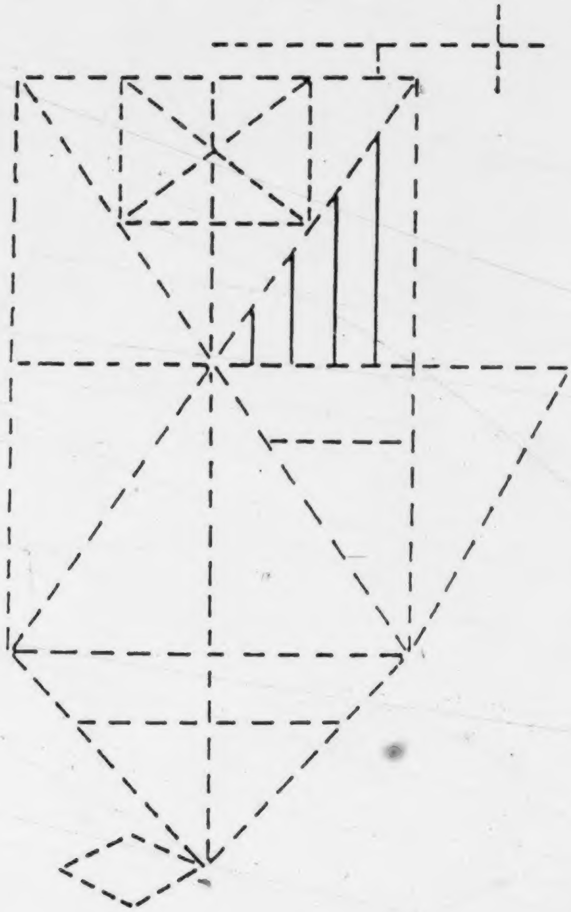
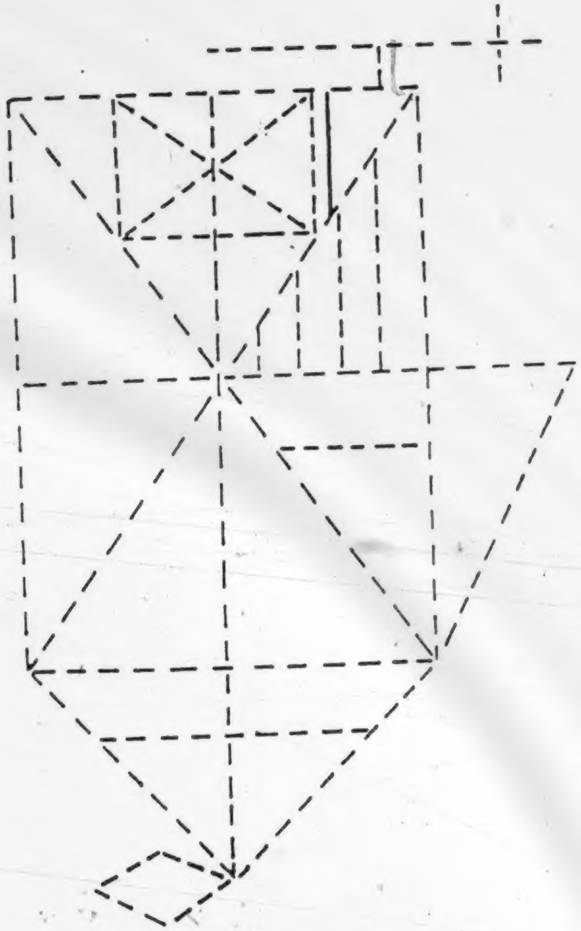
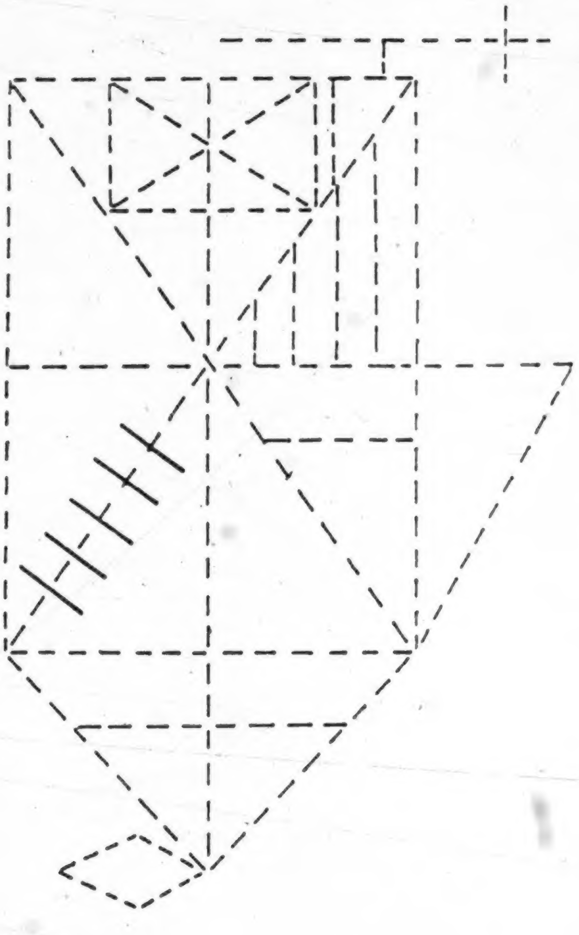
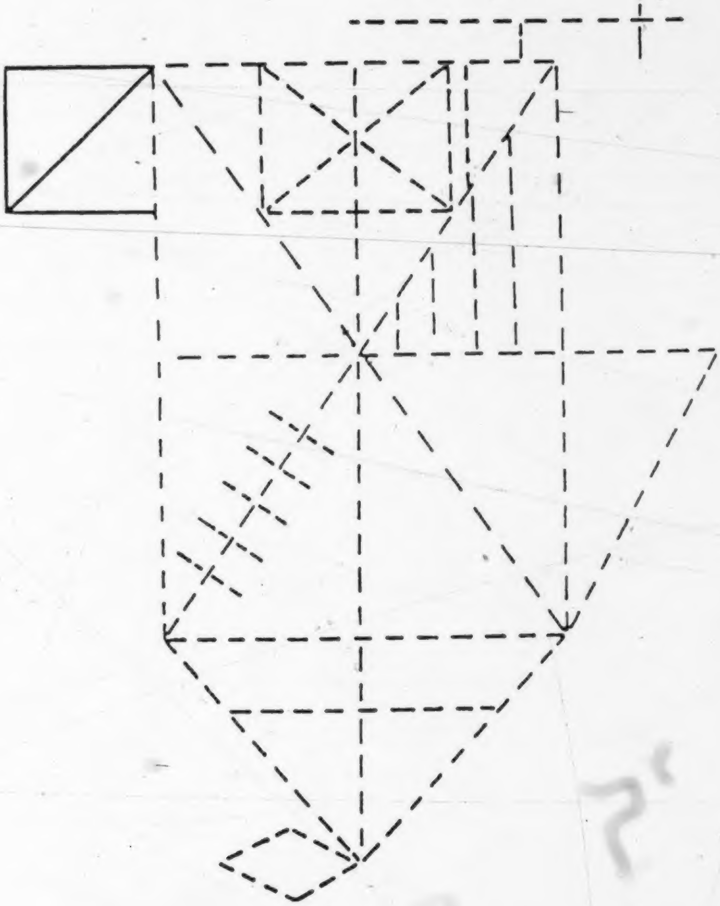
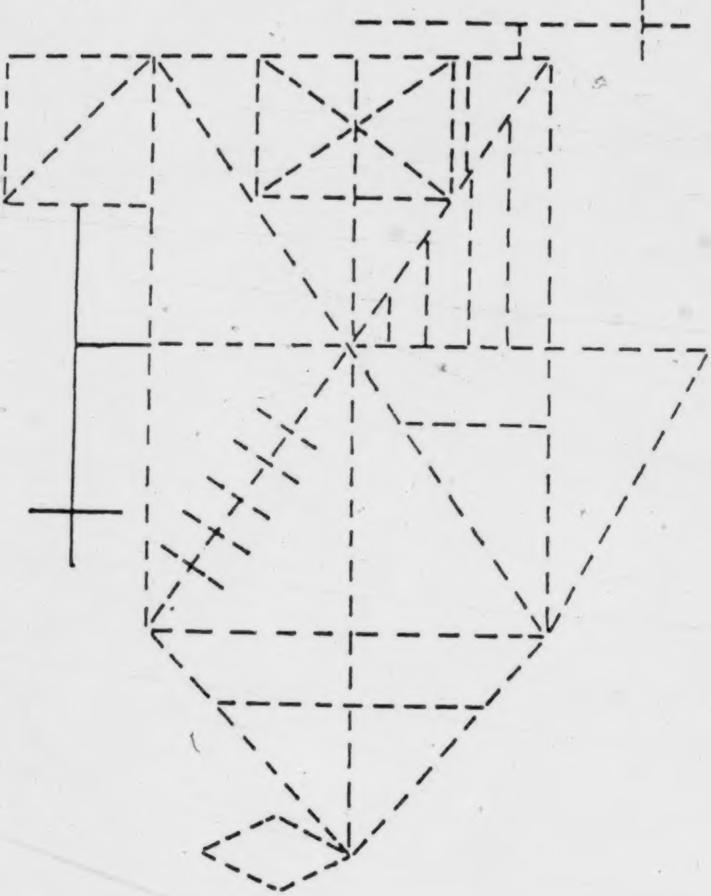
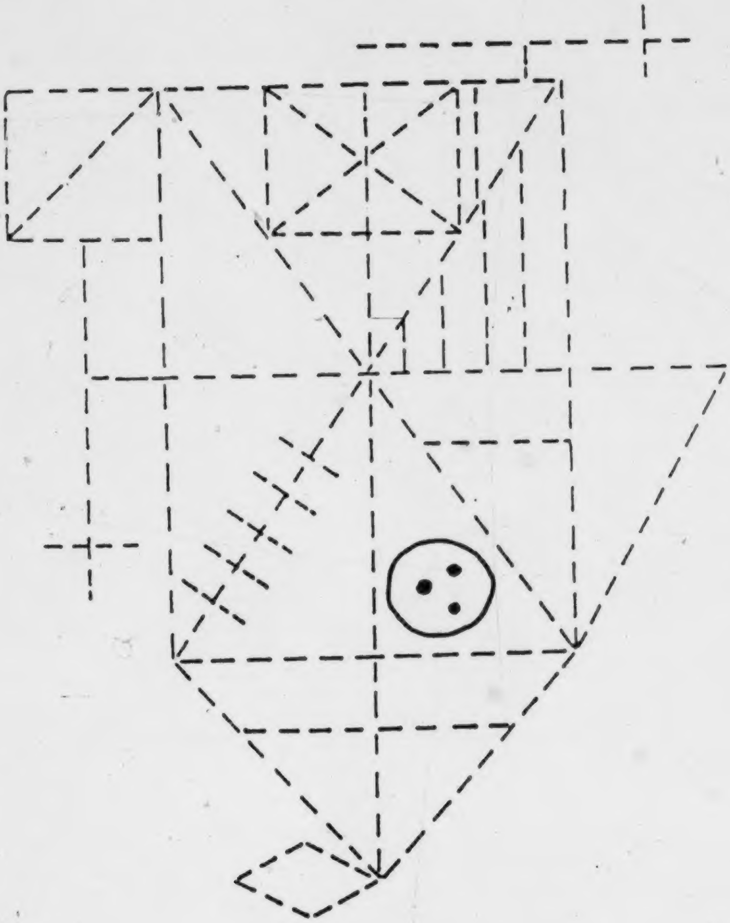
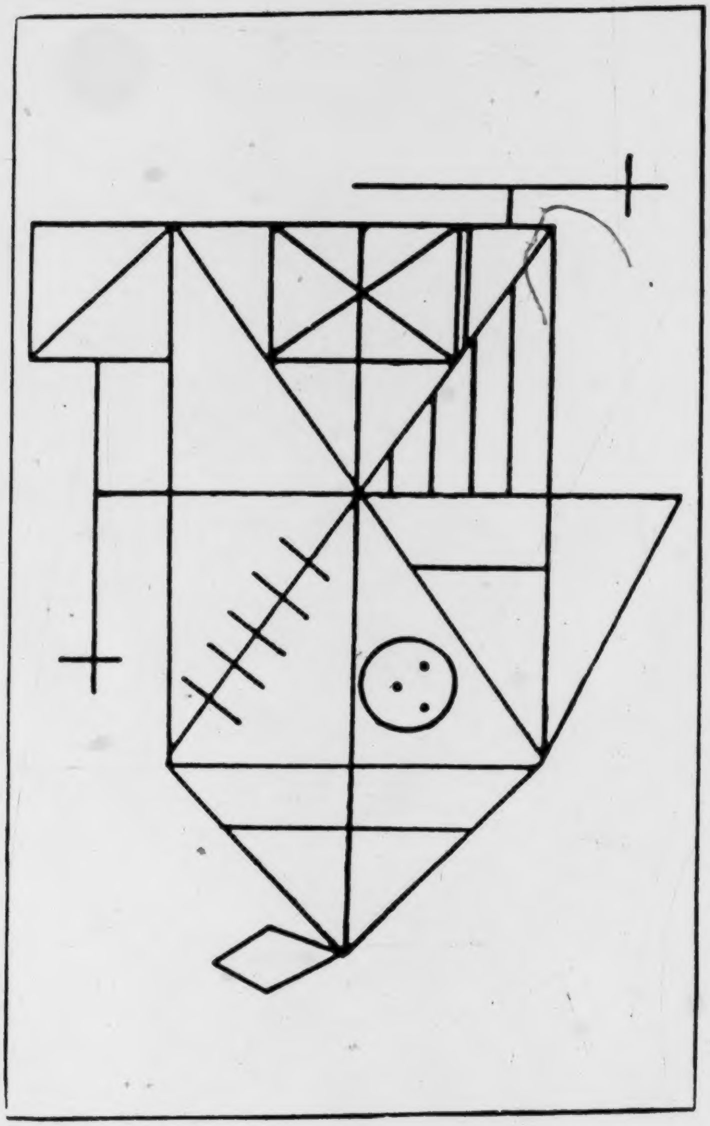
APPENDIX

A. Sequential Complex Figure Test